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Methods of Harvesting and Irrigation in Relation to Moldy Walnuts

BY

L. D. BATCHELOR

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METHODS OF HARVESTING AND IRRIGATION IN RELATION TO MOLDY WALNUTS*

By L. D. BATCHELOR†

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INTRODUCTION

SERIOUSNESS AND DISTRIBUTION OF THE MOLD

For many years the prevalence of mold on walnut kernels has been one of the important causes of reduction in grade of nuts and therefore of loss of money to the walnut growers. A dark discoloration of the kernels is frequently, but not invariably, associated with the mold. In certain sections this trouble has been very bad the past three or four years.

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* Paper No. 109, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

† The author wishes to express his sincere appreciation for the many helpful suggestions in regard to this investigation, made by Dr. J. T. Barrett, Professor R. S. Vaile and Mr. Carlyle Thorpe. The arduous task of cracking thousands of nuts to obtain data was accomplished by the coöperation of Mr. D. C. Wylie of the Field Department of the California Walnut Growers' Association.

The extreme coastal districts and the hot inland regions have not been seriously troubled with mold. In the intermediate sections both the mold and the black kernels have frequently given a great deal of trouble. The hot inland valley sections may be troubled with a high per cent of black kernels even in the absence of mold. The most serious trouble with moldy nuts is usually found on sandy soils.

The economic loss to the walnut grower can be realized by calling to mind the fact that a percentage of over 10 per cent of poor nuts in any lot will necessitate the sale of the whole lot as near-grades,[1] at a probable reduction of 30 to 35 per cent of the value of first-class nuts, the exact value depending upon the actual percentage of poor nuts.

A further reduction in the percentage of good nuts to less than 75 per cent good, will necessitate the whole lot being sold as culls at a loss of another 30 per cent or more of the value of good nuts. The three grades of Santa Barbara soft-shell seedlings, sold by the California Walnut Growers' Association during the season of 1921–1922, returned the following prices to the growers: The first grade ('Diamond Brand')[2] $24.50 per hundred pounds; the near-grades averaged close to $15.00 per hundred pounds, and the culls $7.00 per hundred pounds.

It should not be inferred that all the nuts in the inferior classes are poor quality nuts, but rather that the percentage of poor nuts in the near-grades and culls is too large compared with the good nuts to justify their being sold as a first-class product. It should be clear from this discussion that it takes only a relatively small percentage of inferior nuts to lower the grade and the value of a lot of nuts, the majority of which are of a good quality. If a given lot of nuts is near the border line between the above grades, only one or two pounds of moldy nuts per hundred, may change the commercial value of the whole lot $7.00 to $8.00 per hundred pounds. Most of the moldy nuts cannot be sorted out in the packing house; thus great losses have been experienced in the past which were unavoidable by any means of grading or sorting practiced up to the present time.

---

1 'Near Grades' are an inferior commercial grade in which the good nuts comprise only 75 per cent to 89 per cent of the total. The rest are moldy, shriveled, sun-burned, and generally inedible.

2 'Diamond Brand' is the trade name for the best grade of nuts shipped by The California Walnut Growers' Association and is guaranteed to contain at least 90 per cent perfect nuts.

The efforts of the walnut growers during a period of practically a year are expended on producing high-grade nuts. Good nuts can be changed like magic into the cull class in a week or ten days of improper handling. The work herein reported has shown that the nuts which are finally graded as culls because of mold or dark kernels, were without question first-class nuts at their maturity, a period which should coincide with the beginning of the normal harvest season.

SPECIFIC FUNGI CAUSING MOLDY NUTS

The particular fungi which cause the mold in walnuts have been studied during the past three years by Dr. J. T. Barrett of Citrus Experiment Station, Riverside, to whom the writer is indebted for the following statements:

"Mold in walnuts is not, strictly speaking, a specific disease, therefore, not necessarily confined to the action of a single specific organism. Many fungi and bacteria may grow for a time, upon matured parts of plants which offer suitable conditions of moisture and nutrient material, without actually destroying much of the tissue. The checking of the favorable conditions checks the growth of the organism. Therefore, it was no surprise to find that several fungi could cause moldy walnuts. No doubt many others would produce a similar effect were they present in the groves in sufficient quantity, and at a time when the nuts were in the proper stage for infection.

"Determination of the fungi most commonly associated with the moldy nuts was by means of cultures made by transferring pieces of the mold or mold-bearing tissue of the kernel to a suitable nutrient medium, usually glucose potato-extract agar. Usually within a week to ten days sufficient growth had taken place to make the determination possible. The many cultures made represented sample collections of nuts from more than twenty-five groves distributed in twelve of the main walnut-growing sections.

"The result of these studies revealed that by far the most prevalent fungus in moldy nuts is Alternaria, a genus containing many species, some of which cause very serious diseases of plants, many others occurring as saprophytes only. A little more than seventy-six per cent of the total number of nuts cultured were infected with Alternaria. Less than one per cent showed some other fungus associated with the Alternaria. While no attempt has yet been made to determine the species, the character of growth and spores in the majority of the cultures examined indicates that one species principally occurs.

"The largest number of cultures were made from nuts collected from the six districts most seriously troubled with moldy nuts. It is interesting to note that eighty-five per cent of these cultures developed Alternaria.

"Several other fungi were found in moldy nuts, but not at all consistently, and in a number of cases ranging from one-half to five per cent of the total number of cultures.

"The genera represented are Penicillium (blue and green mold), Cladosporium, Fusarium, Macrosporium (very similar to Alternaria), Mucor, and Sclerotinia (form with small sclerotia). About five per cent of the cultures were negative, and two per cent developed fungi that were sterile and not determined.

"While these studies to date are of a rather preliminary character, the evidence is sufficient to indicate very strongly that the fungus genus most responsible for the moldy nuts, during the past three years is Alternaria. How many species are concerned has not been determined. This with a number of other phases of the problem is to be further studied."

APPEARANCE OF MOLD ON WALNUT KERNELS

In the worst cases of mold the abundance of fungous growth, known as mycelium, is seen as a light to grayish-colored cottony growth on the kernels and inner walls of the shell. If the growth is only slight and largely confined to the diaphragm of the shell, it may not be detected. On the other hand, by the aid of a magnifying glass, strands of fungous mycelium may be detected on the kernel of many first-grade nuts, indicating that under suitable condition most nuts would probably be subject to infection.

On the drying of the nuts the mold dries also, but does not by any means disappear. It retains its fluffy appearance but may collapse somewhat on removal of the shell. There is not a marked difference in appearance of most of the various mold fungi as seen on the kernel. Sclerotinia and Fusarium are usually distinguishable from Alternaria, Macrosporium, and Cladosporium, although one may be frequently mistaken.

ENTRANCE OF MOLD INTO NUTS

Among the many thousand nuts which have been cracked and examined in connection with these studies, no mold has been found in a nut which at the time of examination was incased in a sound husk free from visible cracks and in crisp condition free from

decay. The mold commonly starts to grow in the cracks of the husk which accompany maturity, and spreads thence to the lining of the husk; it quickly spreads through the base and suture of the nut and thence to the diaphragm, and the pellicle of the kernel.

Nuts frequently drop to the ground with the green husk intact. If such nuts lie on the ground a few days the husks begin to decay. Alternaria is the most common cause of this decay. A soft and decayed spot usually first appears on the apex of the shuck. In such cases the mold spreads to the kernel by passing through the suture at apex of the nut.

Even in the worst cases of mold the fungus is superficial on the pellicle and does not actually affect the eating qualities of the kernel except as it presents an inedible appearance.

OCCURRENCE OF MOLD IN SEEDLING AND BUDDED NUTS

The trouble with mold has been much worse among the seedling groves than in the 'budded'[3] ones. This difference is mainly due to the fact that the budded varieties are more apt to drop the nuts from the tree free from the husk.

Many of the old seedling trees are characterized by a high percentage of the nuts dropping as green 'stick-tights.'[4]

The seedlings which more nearly approach the paper-shell type are more likely to shed the nuts as green stickers than the typical Santa Barbara soft-shell type.

The budded varieties, especially of the Santa Barbara soft-shell type such as Placentia and Chase, are, however, not entirely free from this trouble. Moldy nuts have occurred among both of these varieties to a serious degree, when for one reason or another the conditions have been favorable to mold development. The fact that the nuts of budded varieties usually drop free from the shucks is not the only factor which lessens the likelihood of mold among this class of nuts. Another reason is the fact that the majority of the budded groves are younger than the seedling groves, and for that reason are not as apt to become drought-stricken during the growing season as the older trees. As will be shown later, there is a correlation between drought and mold.

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[3] The term 'budded' walnut tree is a trade name to designate the most desirable commercial varieties of nuts which may be propagated by budding or grafting them on black walnut roots.

[4] The term 'stick-tight' has become universally used by walnut growers to designate the nuts which drop to the ground with the husks sticking to them.

VARIATION AMONG SEEDLING TREES

EXTENT OF VARIATION

A group of eighty seedling trees have been under observation for the past three years. The prevalence of moldy nuts produced by the respective trees has varied greatly each year. The range and mean per cent of moldy nuts per tree are shown in table 1. At least fifty[5] nuts per tree were examined in each sample.

TABLE 1

RANGE OF VARIATION AND MEAN PER CENT OF MOLD FOUND IN NUTS FROM A GROUP OF SEEDLING TREES

Year	Total per cent of mold in clean nuts	
	Range among individual trees	Mean of all trees
1920	0—56	16
1921	0—24	7
1922	0—48	11

It is very apparent from table 1 that a group of seedling trees is an extremely variable population as regards this character of susceptibility of the nuts to mold. One tree may produce nuts which are free from mold, while possibly the adjacent tree produces 20 to 50 per cent moldy. Some of the wide variation is probably due to the inherent tendency of certain trees to produce stick-tight nuts, which are more apt to mold than clean nuts.

Some of the apparent variation in the percentage of moldy nuts from different trees may be due to the impracticability of harvesting the crop from each seedling tree when the nuts are in exactly the same state of maturity. Again the variation in the soil and subsoil makes it impossible to have the available moisture in the root zone of each individual tree alike. Such a variation in moisture is bound to be reflected in maturity of the crop, especially in the ease with which the nuts are husked, with a consequent prevalence of mold. From a practical point of view, it is important to know that some particular trees are much more likely to produce moldy nuts than others, as it may become advisable to segregate the moldy nuts in the orchard.

[5] It was found by experience that a sample of fifty nuts gave practically as accurate results as one hundred or more, provided the respective lot from which the sample was drawn was properly mixed, so the laws of chance came into fair play.

LIKELIHOOD OF INDIVIDUAL TREES PRODUCING MOLDY NUTS YEAR AFTER YEAR

The probability that certain trees may produce a large per cent of moldy nuts year after year has been shown to only a small degree by the studies of the past three years. Even though there is a small correlation between the percentage of moldy nuts from individual trees, comparing one year with another, there are many exceptions to this general rule. A strict interpretation of the statistical data[6] at hand not only shows the uncertainty of foretelling the relative amount of mold from individual trees in the future from records of the past; but the harvesting and curing experiments herein set forth show that these last mentioned factors are largely responsible for the prevalence of favorable mold-producing conditions.

RELATION TO SIDE-BLIGHTED NUTS

Inasmuch as the mold organism usually enters the husk after it starts to crack, it was thought that the mold might enter the small fissures in the husk caused by the form of walnut blight commonly known as side-blight. Many nuts which are side-blighted to a slight extent mature as good nuts, even though the husk may be affected with blight. Such blight cankers may not fully penetrate the husk sufficiently to stain the shell of the nut, even though the husk is clearly ruptured by the blight.

During the middle of the 1922 growing season, a large number of side-blighted nuts were covered with gauze bags so the nuts could be identified at harvest time. Likewise an equal number of healthy nuts were covered. Upon examination at harvest time the blighted nuts showed a slightly higher per cent of moldy nuts than the healthy nuts. The difference was more marked among stick-tight nuts than those which dropped free from the husks. A larger per cent of the side-blighted nuts were finally stick-tights than in the case of the healthy nuts.

---

[6] A detailed presentation of the statistical data is not called for at this time. It is sufficient to state here the correlation coëfficients for the per cent of moldy nuts per individual tree in both clean-nut and stick-tight classes were calculated, comparing the following harvest seasons: 1920 with 1921; 1920 with 1922; 1921 with 1922. Although all six coëfficients were positive, the low average of only .33 with a probable error of .07 shows only a low degree of probability that a tree will produce markedly moldy nuts year after year, other factors being equal.

Although there is a positive association of side-blight and mold, it is doubtful if this is a very important factor. Where there is a large enough percentage of mold to be a serious commercial consideration, the majority of cases become infected by other means than through blight cankers in the husks.

RELATION OF CONDITION OF NUTS AT HARVEST TO PRESENCE OF MOLD

MATURITY OF NUTS

The relation of the mold to the progress of the ripening of the nuts was suggested from the records of 1920. This investigation also showed a possible relation of harvesting methods to moldy nuts. Twelve thousand nuts were cracked to obtain this test, relative to the relation of harvest methods to moldy nuts. The nuts were equally divided into three lots: First, nuts which were picked from the trees when matured so the husks were starting to crack; second, clean nuts from ground; and third, stick-tights, the husks of some of which were black and dry when they fell, while others were originally mushy but had lain around until the husks were dried up. The percentage of mold in these three classes is shown in table 2.

TABLE 2

PROGRESS OF MOLD DEVELOPMENT IN NUTS AT DIFFERENT STAGES OF MATURING, AND CONDITIONS AT THE SAME DATE OF HARVEST (1920 CROP)

Classification	Moldy culls	Moldy but passable	Total mold
Nuts picked from trees when husks started to crack	6%	4%	10%
Clean nuts from the ground	7%	8%	15%
Black stick-tight nuts from ground	13%	14%	27%

The moldy nuts were divided into two classes according to the amount of mold present: (*a*) moldy culls; (*b*) moldy but passable. In the latter class the mold was clearly visible on the kernels, but not bad enough to condemn them as culls. At the same time there was a certain additional percentage of nuts which showed only such small traces of mold that they were classed as first-class nuts.

It is clear from a study of the summary that a delay in harvesting is bound to permit the mold to increase. Even the nuts picked from the trees were 10 per cent moldy. As some of this mold was passable, however, it would not have barred them from the best grade if they had all been periodically harvested as soon as the husks cracked. Many of the nuts in the lots picked off the trees had been held in the clasp of the partly opened husks for several days. The prompt harvesting of the nuts would have prevented the development of the mold, and have made the whole crop grade as Diamond Brand. A delay of several weeks would have allowed the whole crop to become so moldy that it would have graded as near-grades or culls. This point is brought in again in several of the following summaries:

MOLD INCREASE AS HARVEST SEASON ADVANCES

(Harvested according to ordinary methods)

Harvest and cracking records were kept from a group of trees near Anaheim during 1922. The nuts were picked up three or four times between September 28 and November 1. The trees were shaken each time, except at the first picking. One hundred nuts per tree were cracked at each picking to determine the amount of mold in the clean and stick-tight nuts. Table 3 shows the increase in the percentage of mold as the harvest season advanced.

TABLE 3

INCREASE IN PERCENTAGE OF MOLDY NUTS AS THE HARVEST SEASON ADVANCED

	1st pick (Sept. 23-28)		2d pick (Oct. 10-14)		3d pick (Oct. 25-Nov. 1)	
	Moldy culls	Moldy but passable	Moldy culls	Moldy but passable	Moldy culls	Moldy but passable
Clean nuts	3%	6%	4%	9%	4%	10%
Dry stick-tights	9%	16%	12%	18%	15%	28%
Green stick-tights	1%	5%	23%	27%	.....	.....

Table 3 as well as table 2 shows that the dry stick-tight nuts are much more likely to be moldy than clean nuts.

This is again brought out in table 4 which shows a summary of the records of all three years. The main purpose of table 3, however, is to show the increase in percentage of moldy nuts as the season advances.

With the clean nuts and the black, dry stick-tights there was an increase in moldy nuts, comparing the first pick with the second one. Still further increase of mold was noted in the black stick-tights between the second and third picks.

This big increase in mold is bad enough in the clean nuts and black stick-tights, but an even greater increase is shown by the green stick-tights.

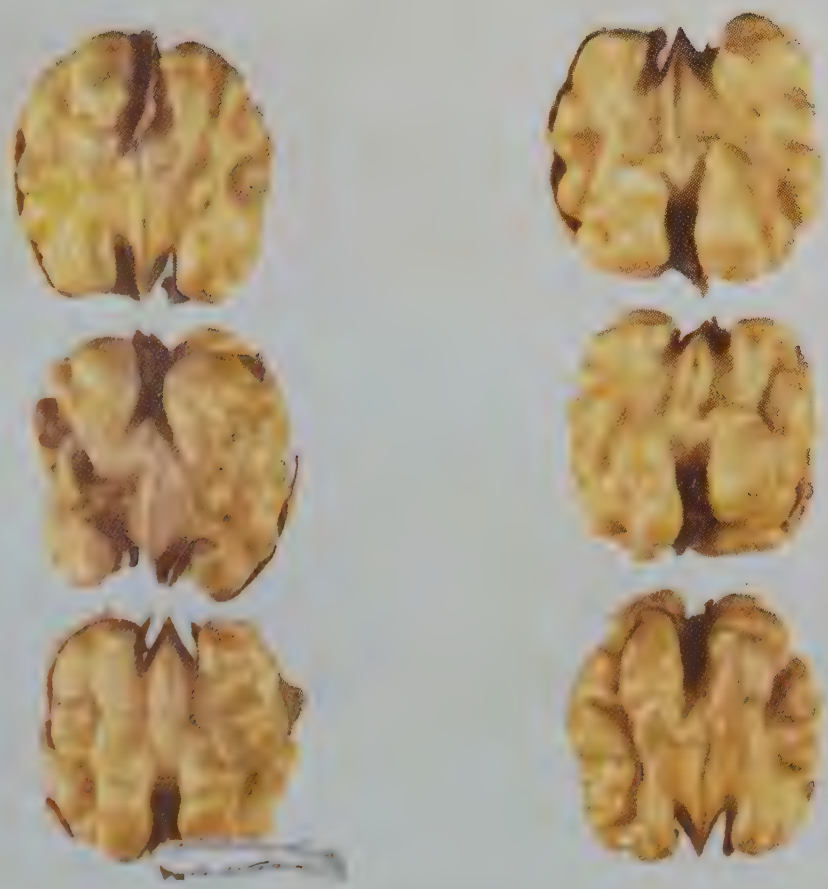
This last mentioned class of nuts was practically free from moldy culls at the first picking. Twelve to fourteen days later, when the trees were shaken for the first time, the green stick-tights were 50 per cent moldy with 23 out of every 100 nuts reduced to moldy culls. Some of the green stick-tights of this second pick were already on the ground before the trees were shaken. Possibly 50 per cent of them were shaken off.

It is interesting to note what 100 pounds of the green stick-tights were worth at the first pick compared with the second one.

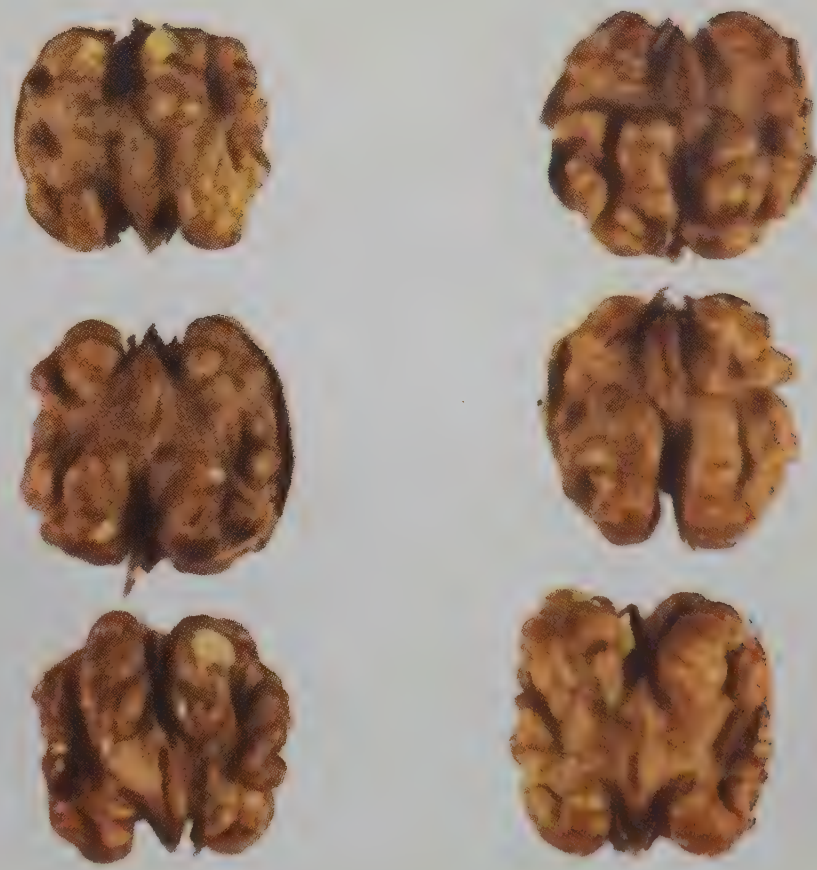
With such nuts originally grading as Diamond Brand when properly harvested, they were worth $22.50 per 100 pounds. Although there were 50 pounds of good nuts in every 100 pounds of the second pick, they could not be sorted out of the near-grades and culls. At the very best the whole lot could scarcely be counted on to grade as near-grades, valued at $15.00 or less per 100 pounds. A few more days delay in harvesting would, no doubt, have made culls of them, worth possibly $7.50. It is only a matter of combining plain arithmetic and good judgment to see that it would pay big dividends to speed up the harvest of green stick-tights, even to the extent of spending fifty cents per 100 pounds or more as an extra bonus for harvesting and shucking this type of nuts. It would also require, no doubt, more personal supervision of the laborers by the grove owner, which is a good thing on general principles, and would be well paid for in such a case as above illustrated.

MORE MOLD AMONG STICK-TIGHTS THAN CLEAN NUTS

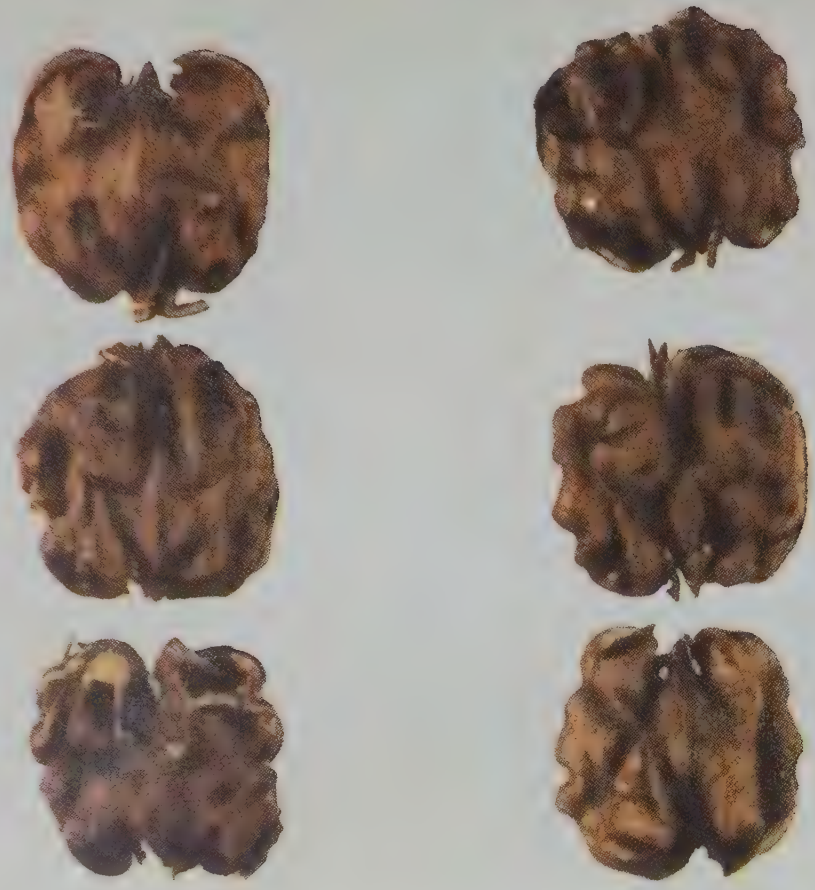
In tables 2 and 3 it has already been shown that stick-tights are more apt to be moldy than are clean nuts. The following table summarizes the observations for all three years. With the large number of nuts observed (28,451) to make this comparison, the small errors of sampling, and the personal errors of judgment have been leveled by the laws of chance. It becomes a practical certainty that stick-tight nuts at harvest are likely to include somewhat more than twice as many moldy nuts than are the clean-shelled nuts.



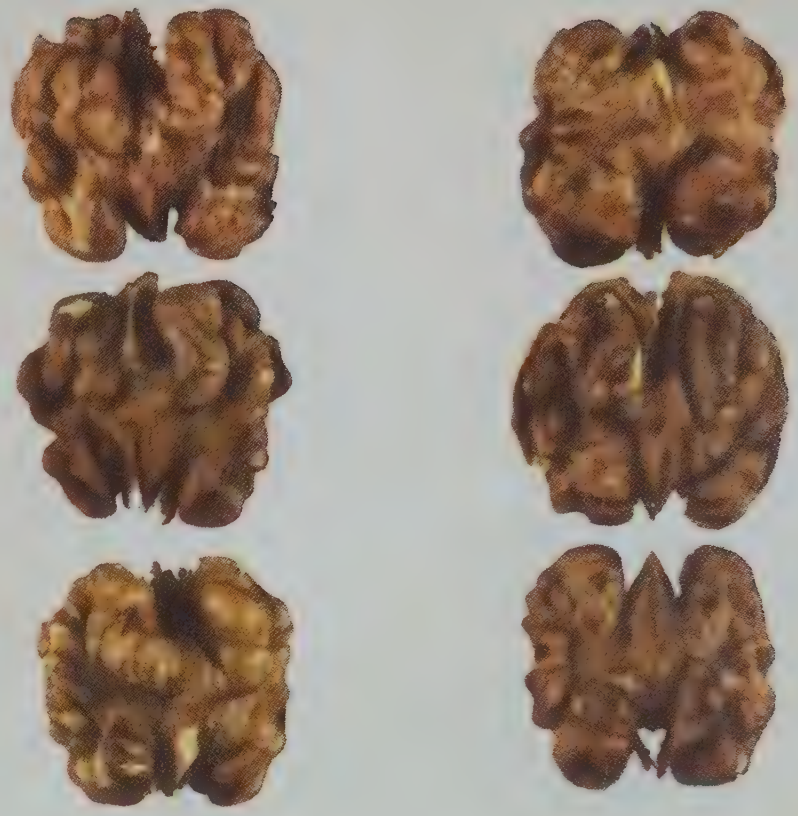
a. Green "stick-tights," husks still firm.



b. Green "stick-tights," husks partly soft.



c. Green "stick-tights," husks become partly black and mushy.



d. Green "stick-tights," same as lot (a) but left on ground 11 days until husks became mushy.

Fig. 1.—Progress of kernel discoloration in "stick-tight" nuts due to delay in shucking.

(Courtesy of California Walnut Growers Association)

TABLE 4

PERCENTAGE OF MOLDY NUTS IN CLEAN AND STICK-TIGHT NUTS
(Result of 28,451 counts)

Class	Moldy culls	Moldy but passable	Total moldy nuts
Clean nuts	4%	7%	11%
Stick-tights	11%	17%	28%

The summary in table 4 includes four different crops from two groves. Nuts from 120 trees are about equally represented in this summary. In all cases when any considerable number of trees, say from 8 to 20, were grouped together, the trend of the results, without any exception, was the same as the above. Although it was clear at the end of the 1921 season that most of the moldy culls traced back to the stick-tight nuts, it was equally clear that a certain amount of mold occurred in the ordinary harvest of typical clean-shucked nuts.

The separation of these two classes of nuts in the orchards would no doubt lessen the trouble in grading the crop. It is stopping short of the real issue, however, to leave the question here without finding out more about the cause of even the small amount of mold in the clean nuts. The work was, therefore, enlarged in 1922 to include observations on the relation of the mold to harvesting methods as well as an attempt to reduce the number of stick-tights, and thus the large amount of mold.

RELATION OF DELAY IN HARVESTING TO PERCENTAGE OF MOLDY NUTS

The increase in per cent of moldy nuts, heretofore discussed in table 3, took place under ordinary harvesting conditions.[7] The trees were shaken at each picking, except the first one, and all the nuts picked up. Most of this increase in mold took place while the nuts were still on the trees, held within the clasp of the partly opened husks.

With this increase in mold under normal conditions of harvesting, it is now of interest to see what takes place when the nuts are

[7] The nuts are gathered two or three times by the ordinary harvesting methods. Frequently the nuts are allowed to lie on the ground in the grove from a week to ten days between pickings.

allowed to lie on the ground for several weeks, as they often do, under slack harvesting methods. Several trials were made at the beginning of the 1922 season. Nuts from the first picking, both clean and stick-tights, were left on the ground in the groves to determine the effect of this delay of harvesting on the mold. The first counts of the mold were made when the nuts would ordinarily be picked up (September 20 to 29). The second count from the respective groups was made a week or ten days afterward, and the third count (November 1), at the end of the harvest period.

The rapid increase in mold is shown by table 5, which summarizes the results of two tests.

TABLE 5

RAPID INCREASE IN PERCENTAGE OF MOLDY NUTS BY DELAY IN HARVESTING NUTS WHICH FELL AT BEGINNING OF SEASON (NUTS FROM FIRST PICK LEFT ON GROUND IN ORCHARD)

	1st crack (Sept. 28)		2d crack (Oct. 12)		3d crack (Oct. 21)	
	Moldy culls	Moldy but passable	Moldy culls	Moldy but passable	Moldy culls	Moldy but passable
Clean nuts	6%	12%	16%	10%	15%	11%
Black stick-tights	10%	17%	20%	18%	19%	18%

The rapid increase in the mold on these early ripening nuts occurred during the first week or ten days of harvest. After this time the nuts were largely cured on the ground, and there was no increase of mold from then until the end of the season. In fact these early nuts from the first pick were changed from Diamond Brand to near-grades by a delay of eight to ten days in picking them up. On the other hand, the third picking of stick-tights summarized in table 3 shows even more mold than the stick-tights just mentioned which laid on the ground for nearly forty days. This is due to the fact that most of this last class tabulated in table 5 were dry and crisp when they fell, while the third regular pick included many mushy stickers.

This brings us to the necessity of a somewhat clearer understanding of stick-tights. There are two or three distinct classes produced by as many distinct causes and with radically different kinds of kernels in them.

First, there are the dried-up black-husked stick-tights, the husk of which usually turns completely black while hanging on the tree. Such stick-tights are caused by a stem rot which may be in evidence as early as the middle of August. Many of the nuts in this class are borne in the centers of the trees, a fact which shows that their condition has no relation to heat or sunburn. Such nuts when picked off the trees usually show about 10 per cent moldy culls, and from 20 per cent to 40 per cent moldy but passable kernels. About 50 per cent usually show good, sound, white kernels. The kernels in this class, as a whole, are not quite up to normal plumpness. No doubt the premature stopping of the growth of the nut by the rot of the stem is responsible for the lack of plumpness.

The black, dry stick-tights discussed above, however, usually fail to account for many of the dark-meated culls, and the high percentage of mold that may be found under certain trees, or in certain loads of near-grades which reach the packing-house. With this fact in mind, a close account was kept of the second type, the green stick-tights, during the 1922 season. The green stick-tights are usually associated with lack of late summer irrigation. Many counts of the mold were made of samples of these green stick-tights which were allowed to lie on the ground in the grove until they became mushy. This mushy condition of the stick-tights exists all too often in many commercial groves. A large lot of green stick-tights were gathered on September 20, and will serve as an example of other similar experiments. A sample of 100 nuts was cracked on this date. The remainder of the lot were left in the grove with the husks on them and cracked as noted in table 6. A rapid increase in the percentage of mold followed as the husks became mushy. Finally, some time before the end of the season, the husks were completely dried up, and the nuts thus resembled the black stick-tights.

TABLE 6

SHOWING INCREASE IN PERCENTAGE OF MOLDY NUTS IN GREEN STICK-TIGHTS LEFT IN THE GROVE THROUGH THE HARVEST SEASON

When picked up Sept. 20		Left with husks on, on the ground					
		Sept. 28		Oct. 12		Nov. 1	
Moldy culls	Moldy but passable	Moldy culls	Moldy but passable	Moldy culls	Moldy but passable	Moldy culls	Moldy but passable
1%	2%	15%	16%	17%	17%	13%	43%

The green stick-tights which were husked as soon as the husks were wrinkled slightly and before they decayed, showed only 3 per cent total moldy nuts, while the kernels were notably white and of fine quality. After lying on the ground through the harvest season the total mold was 56 per cent instead of 3 per cent. Practically all the kernels were amber or black at the last sampling, and in fact, the whole lot were culls pure and simple. The outside of the shell, except for a little stain, showed no clue to the condition of the meats. Green stick-tights, handled somewhat as in this experiment, produce many of the near-grades and culls. They account for more trouble than the black, dry stick-tights on the trees, for the latter, as noted before, may have 50 per cent of good meats. In France the nuts are gathered green and husked, and are seldom moldy. This is in harmony with the above observations and probably accounts for the lack of mold in the French nuts. The colored cuts in figure 1 are presented to show the change in grade of the nuts due to the white kernels of a green stick-tight turning to amber or black. if the husk is allowed to stay on it until it becomes mushy. Cuts *a*, *b*, and *c* show the progress of discoloration in a lot of nuts picked up from one tree at the same time but divided into three classes: *a*, firm green stick-tights; *b*, green stick-tights starting to soften; *c*, mushy stick-tights. The amount of mold in these classes cannot be shown by the photographs; the total per cent of moldy nuts in the above classes at the time the nuts were picked up was as follows: 0, 24 and 88 per cent, respectively. The nuts shown in cut *d*, were firm green stick-tights taken from the same lot of nuts as lot *a* at the time of picking, but left on the ground until they became mushy. During a period of eleven days the nuts lay in the grove as they would under natural conditions of slack harvesting methods. The total mold in lot *d* increased from 0 to 73 per cent. Meanwhile the kernels had turned from first-class white meats, as shown in cut *a*, to practically all amber meats and culls, as shown in cut *d*.

RELATION OF SUNBURNED NUTS TO PREVALENCE OF MOLD

While the mold in stick-tights is under consideration, the results of observations on sunburned nuts may also be considered, inasmuch as most sunburned nuts are also stick-tights. In the popular mind, sunburning and mold are walnut troubles which go hand in hand. The fact that the extreme cases of mold are not necessarily tied up with sunburned nuts, was shown without question during the

present season. Most of the sunburned nuts drop with the green shucks on, showing a black spot on one side of them. Frequently the shucks are not cracked on such nuts, and seldom do they crack open enough to let the nut fall off the tree free from the shuck. The sunburned nuts often, in reality, are one form of the green stick-tights. Several large lots of these nuts were gathered and cracked periodically, to see if the mold was an unfailing partner to the sunburning on the nut. Table 7 summarizes an experiment which will illustrate the trend of all similar tests.

TABLE 7

SHOWING INCREASE OF MOLD IN SUNBURNED NUTS BY DELAYING HARVEST

Method of handling	Percentage of moldy nuts		
	Moldy culls	Moldy passable	Total moldy
Cracked as picked up (Sept. 29)	16	8	24
Shucked and cured in trays (cracked Oct. 12)	14	6	20
Left in grove with shucks on (cracked Oct. 12)	32	13	45
Left in grove with shucks on (cracked Nov. 1)	37	28	65

There is no question but that sunburned nuts, as they are gathered under normal harvesting conditions, are apt to be moldy, but it is equally clear that good marketable lots of near-grades can be made out of such nuts, if they are picked up promptly, shucked and cured normally. On the other hand, throwing such nuts up against the trees to be left there until they become mushy and shuck easier, will make culls out of practically the whole lot, with the mold increasing from 25 per cent up to 65 per cent or more.

In connection with this table the question may be raised, why the cured nuts showed less mold than those cracked when they were picked up. It has been consistently noticed that the same degree of mold shows up less in a thoroughly cured nut than in a green one. A small percentage of any lot of nuts will pass as practically sound when thoroughly cured which would be at least "moldy but passable" if judged before curing.

A sunburned nut is usually characterized by having one-half of the kernel blackened by the sun injury. For this reason they should not be mixed with the good nuts, regardless of the presence of mold. Although they might possibly be graded as near-grades, they

will not be a very commendable lot. Possibly such nuts should be kept separate in the grove, and sent to the cracking plant as culls, rather than lower the grade of good nuts by being intermixed with them.

RELATION OF CURING TO PERCENTAGE OF MOLDY NUTS

Clean nuts harvested in the ordinary manner are not likely to show any change in the percentage of moldy nuts due to any methods of curing.

Table 8 shows the result of a test taken in 1920. Clean nuts, harvested by ordinary methods, from the second picking were used for this test. Possibly some of these nuts had been on the ground in the grove a week or more before they were harvested.

TABLE 8

EFFECT OF RAPID AND SLOW CURING ON PERCENTAGE OF MOLDY NUTS

	Moldy culls	Moldy but passable	Total moldy
Sampled in grove when picked up	7%	8%	15%
Cured rapidly	8%	8%	16%
Cured slowly	7%	9%	16%

The rapidly cured nuts were spread in a thin layer in a laboratory and exposed to a breeze from a powerful electric fan for five days. The slowly cured ones were kept for five days in paper bags placed in a room where the humidity was maintained at nearly 100 per cent for the entire period. Both lots were then exposed to common-storage temperature and humidity until they were cracked. It is clear from the above summary that there was no further development of mold after the nuts left the orchard. Of course, all such cleaned-shelled nuts are partly cured as they lie on the ground in the grove.

RELATION OF IRRIGATION TO PERCENTAGE OF MOLDY NUTS

It has long been felt that the bad outbreaks of mold were associated in some way, with irrigation or cultural practice. Observations were made on this point during 1922, which show that irrigation late in the growing season to promote the cracking of the husks, making the nuts drop clean with few or no green stick-tights, is the first and most practical precaution to take in preventing moldy nuts. There is no doubt that in this indirect way, that is, through

the effect of irrigation on the green stick-tights, much of the trouble with moldy nuts is traceable first, to poor irrigation practice, and second, to lack of good harvesting methods.

Table 9 shows the results of an irrigation trial in the Anaheim district, during the 1922 season. Both plot A and plot C were well irrigated up to the first of August. After this date plot A received 7 acre inches per acre on August 8, and a like amount on September 7, while plot C received nothing. The rainfall was of no consequence from August 1 until the end of the harvest season. The contrast in the soil moisture condition in these two plots may be illustrated by the samples taken August 15 and September 12 summarized in table 9.

The samples were taken as soon as the soil could be cultivated following a heavy irrigation.

The amounts of moisture observed at these two periods are a close approach to the maximum water-holding capacity of the soil in plot A under field conditions.

TABLE 9

COMPARISON BETWEEN THE SOIL MOISTURE PRESENT[8] IN PLOTS A AND C DURING THE LATTER PART OF THE GROWING SEASON AND THE FOREPART OF THE HARVEST PERIOD

Plot	Ft.	Hygroscopic point		Ratio of moisture content to hygroscopic point			
				Aug. 15 1922		Sept. 12 1922	
		A	C	A	C	A	C
	1	4.40	4.69	2.95	1.64	3.18	1.22
	2	2.64	3.47	4.03	2.02	4.13	1.35
	3	1.86	6.85	4.74	1.90	4.24	1.31
	4	4.71	8.02	2.10	1.67	2.48	1.10
	5	6.19	5.32	2.94	1.79	2.56	1.50
	6	3.71	4.72	3.37	2.08	3.13	1.57
	7	1.87	3.71	4.51	2.83	4.23	1.35
Mean				3.52	1.99	3.42	1.34

[8] The hygroscopic coëfficient was determined by the conventional indirect method originated by Briggs and Shantz. A 30-gram sample was used in all cases for this determination.

The moisture observed is stated as a ratio to the hygroscopic coëfficient. This seems to be the most effective way of acquainting the reader with relative moistures of the soil. For the information of those not used to thinking in the terms of present-day soil moisture studies, it may be stated that 1.47 times the hygroscopic coëfficient equals the wilting point of annual plants, while 2.71 times the hygroscopic coëfficient equals the moisture equivalent.

From data obtained previous to those presented in table 9, it is certain that the soil moisture in both plots A and C averaged above the wilting point throughout the first part of the growing season, April to July inclusive. From the first of August on, the soil moisture in plot A was kept well above the wilting point. Some time about the first of September, the soil of plot C had reached a dryness which would have caused annual plants to wilt and was approaching the hygroscopic point by the middle of September.

The contrast in soil moisture was clearly reflected in the maturity of the trees. The trees in plot A remained green throughout the harvest period of September and October. Probably less than 10 per cent of the leaves had dropped by October 30.

In contrast to this, the leaves began to drop from the trees on plot C during the middle of September, and by October 30 many of the trees were entirely bare of foliage. Probably 90 per cent of the leaves of the plot were on the ground at this last mentioned date.

TABLE 10

CONNECTION BETWEEN LACK OF WATER IN THE LATE SUMMER AND STICK-TIGHT AND MOLDY NUTS

	Per cent crop dropped as stick-tights[9]	Per cent of total crop moldy		
		Moldy culls	Moldy but passable	Total
Plot A (continually well irrigated)	22%	5%	12%	17%
Plot C (dry in latter part of August and in September)	52%	8%	17%	25%

The close relationship between the lack of soil moisture to stick-tights, and thus the prevalence of moldy nuts, is clearly shown by table 10.

In addition to the culls, due to mold, the dry plot produced about 20 per cent culls because of black meats from the mushy stick-tights. Meanwhile the well-irrigated plot showed less than 10 per cent additional culls from all other causes, and could easily have been graded as Diamond Brand. The entire crop from the dry plot, with 25 per cent culls, would hardly make the near-grade class.

[9] The dried-up black-husked stick-tights, discussed on pages 686 and 689 are figured in the total per cent of stick-tights for both plots. During a year when this particular type of stick-tight was less prevalent, the contrast in the percentage of stick-tights due to irrigation would be even more marked than during the 1922 season.

Each 100 pounds of nuts from the crop of the dry plot was actually worth at least $7.50 less than an equal amount from the well-irrigated plot. With only an average crop of nuts (825 pounds per acre) this would mean a loss of $61.88 per acre. An extra run of water would have been a paying investment.

If a grower has failed in following up his irrigation correctly, he can still rescue the crop in first-grade condition by proper harvesting. If he is slack in both of these practices, there is a very small likelihood of obtaining anything but near-grades and cull nuts.

SUMMARY

The work has shown conclusively that nuts will mold readily on the trees at any time after the husks start to crack, the mold starting its growth on the damp lining of the husk and finally spreading to the kernel. The vast majority of the nuts which are going to be moldy are in this condition before they reach the curing yards. The mold makes nearly all its growth while the kernels are still very moist. The first drying out at the beginning of the curing process checks any further development. The percentage of moldy nuts increases rapidly if the harvesting operations are delayed, especially if the nuts are still in the husks, even though they are partly cracked open and still on the trees. The percentage of moldy nuts is greater in stick-tights than in clean nuts. As the harvest season advances, the increase of mold is more pronounced in stick-tights than in clean nuts. The increase in percentage of mold among nuts left in the orchard is much greater in the case of green and mushy stick-tights, than in the case of black, dry stick-tights, since the latter dry up and partly cure while still on the trees. The percentage of the crop which falls as green or mushy stick-tights is much greater in groves which were not adequately irrigated during the very last portion of the growing season.

PRACTICAL RECOMMENDATIONS

1. Use enough late summer irrigation water so the trees hold their leaves through the harvest season, and the nuts drop free from the husks.

2. Hasten the harvest in general; shake the trees at the first picking, and have crew enough to go over the entire orchard once a week, shaking the trees each time.

3. Any trees that show a tendency to produce green stick-tights should be stripped of the crop the first time over and husked by hand, if necessary. Such nuts will have to be husked sometime; if they are taken in time they will be first-grade nuts, but if they are neglected, and the husks become mushy, they will be culls.

4. Knock off all the black stick-tights at the first picking, and husk them promptly.

5. Keep all the dry stick-tights, mushy stick-tights and sunburned nuts separate from the rest of the crop in the grove and curing yards, and deliver them to the packing-house separately. They are only near-grades at the best, and if they are kept separate from the rest of the crop, it will save much money and trouble in the packing-house not to have to attempt to pick them out of the better nuts. Furthermore, if the grower mixes too many of the black and mushy stickers in with the clean-shelled nuts, the whole lot may have to go as near-grades. Any attempt to fool the packing-house manager, by mixing good nuts with poor ones or *vice versa,* is very short sighted, not only for the immediate financial returns of the grower but for the good name of California walnuts. It is the first duty of the packing-house manager to grade the poor nuts out of the good ones, so don't add to his duties and the growers' expense by knowingly letting nuts with a high percentage of mold get in with the good lots.

6. The mold in walnuts is there, in the great majority of cases, before they reach the curing trays. Under any reasonably good method of handling the nuts on the trays, the mold will not increase during the curing process.

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TESTS OF FARM ORGANIZATION IN THE TURLOCK AREA

R. L. ADAMS AND L. A. CRAWFORD

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TESTS OF FARM ORGANIZATION IN THE TURLOCK AREA[1,2]

R. L. ADAMS[3] AND L. A. CRAWFORD[4]

INTRODUCTION

To obtain the highest income consistent with the size of farm and the farm enterprises which are or can be conducted is the primary aim of most farm operators. In addition to size of farm and choice of enterprises, the earning power of any farm is also affected by the yields now being procured or which can be procured; by the selling prices now being obtained or which may be obtainable from the sale of farm products; by the necessary expenditures required to carry on the farm business; and, finally, by the ability of the operator. These six factors constitute or vitally affect every plan of farm organization, either existing or proposed, and largely determine the earning power of every farm.

The form of organization may center on some single enterprise (the specialized type of farming) or on several major enterprises (the general, or diversified, type of farming). The enterprises may consist of various crops—field crops, fruit, or truck crops; or of livestock—sheep, beef cattle, hogs, dairy cattle, or poultry. When combined under one organization, enterprises assume either complementary, supplementary, or competitive relations. Complementary enterprises are those which support one another or contribute jointly and interdependently to the earnings of the farm, such as the production of hay or grain to be fed to livestock; the use of skim milk produced in a dairy for feeding hogs, calves, or poultry; or the growing of legumes for their beneficial effect upon subsequent crops. Supplementary enterprises are those which dovetail into one another in the use of land, labor, equipment, and management, such as grain followed by beans or corn; winter vegetables raised in conjunction with summer orchard fruits. Competitive enterprises are those which vie with one another in the use of land and other

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resources of production and thus tend to crowd each other in the farming plan, such as beans and corn; alfalfa and cotton; cherries and apricots. Recognition of these relations is essential in the selection of enterprises and the determination of the number and size of each enterprise to combine into one organization in order to develop a well-balanced, readily workable plan. Conditions which affect the choice of enterprises include:

1. Suitability of the physical environment—soils, topography, elevation, climate, supplementary water supplies, drainage, pests, etc., as these affect yields.
2. Accessibility and receptivity of available markets, as these affect price returns.
3. Degree of complementary, supplementary, or competitive relations between enterprises, as this affects the operation of the entire farm.
4. Degree of permissible and justifiable diversification or specialization, as this affects the operation of the entire farm.
5. Suitability and availability of required hired help, as this affects yields and expenditures.
6. Necessary expenditures to provide materials (seeds, spray materials, irrigation water, sacks, boxes, or other market containers).
7. Cost of using motive power (horses, tractors, trucks, and automobiles).
8. Cost of using equipment.
9. Outlays required to market the product.
10. Taxes, as these affect expenditures.
11 Suitability of the equipment; and, if additional investments are required, the nature and amount of these added investments.
12. The ability of the operator, as this affects production, expenditures, and marketing.
13. Earning power, as determined by 1 to 12 inclusive, plus the available acreage.

The purpose of this publication is to present in detail a method of making an intensive business analysis of various types of farm organizations to determine the present earning power and to test proposed changes in the existing plan of organization as these affect the earning power of the farm.

Subjecting a plan of farm organization to business tests, after the manner described in this text, enables the farm operator to find out what the farm is now earning, assists in determining the feasibility of proposed plans, indicates the possible financial outcome, and may suggest further improvements which can or should be made to obtain larger

earnings from the resources at the operator's command. As already indicated, the test of any proposed plan is net income, and this can be determined only after detailed information has been carefully assembled concerning possible yields, selling prices, the number and nature of the various cultural operations, and the time required to perform them, and expenditures required in the operation of each farm property and for each plan of organization.

AREA SELECTED FOR STUDY

The data which form the basis of the tests of various plans of farm organization presented in this publication were drawn from the area about Turlock, California. This is an important agricultural district of the San Joaquin Valley and was selected because the agriculture of this locality is well established and farming practices are standardized. It is an intensively farmed area of relatively small farms. The agriculture is sufficiently diversified so that it includes dairying and poultry keeping and a rather extensive list of field crops, fruits, and truck crops. A specific request was made of the College of Agriculture for a farm management study in this area.

This area consists of about 120,000 acres of well-developed farming land surrounding the city of Turlock, and comprises portions of southern Stanislaus and northern Merced counties. It is roughly rectangular in shape, about 12 miles wide by 16 miles long, and is bounded on the north by the Tuolumne River, on the west by selected section lines close to the San Joaquin River, on the south by the Merced River, and on the east by selected section lines lying contiguous to rolling dry-farmed grain lands. These boundaries are shown on the sketch map (fig. 2) illustrating this paragraph.

These farmed lands lie on the floor of the San Joaquin Valley at elevations from about 55 feet to 150 feet above sea level and form a rather level, continuous plain which slopes generally in a southwesterly direction at variable rates of from 5 to 25 feet per mile.

The area is part of the Turlock Irrigation District, formed in 1887, which today has about 137,000 acres under ditch. Water for irrigating is impounded behind large dams on the Tuolumne River and conveyed to the different farms of the area through a network of canals and ditches, of which about 38 per cent are concrete lined. A system of drainage ditches supplemented by a number of large electrically driven pumps, pumping from shallow wells, effectively controls the depth of water table.

The rural population numbers about 15,000 and in addition there are the incorporated cities of Turlock (population 4,271) and Ceres (population 981)[5] and the unincorporated towns or settlements of Hughson, Denair, Keyes, Hilmar, and Irwin (having an estimated total population of about 950).



Fig. 1.—Location of the Turlock area, California.

The rural areas are well supplied with an extensive system of roads, including many that are surfaced with concrete, giving easy access to all parts of the district and making stations on the Southern Pacific and Santa Fe railroads readily accessible shipping points for growers.

[5] Population figures from U. S. Dept. of Com. Bureau of Census. Fifteenth Census of the United States: 1930. Population; California, table 5.

A network of power lines traverse the area supplying electric power to a majority of the farms in the area.

The climate of this section of California is divided into a rainy season which commonly extends from early in November to May, and a dry season which lasts for the balance of the year. Temperatures only occa-

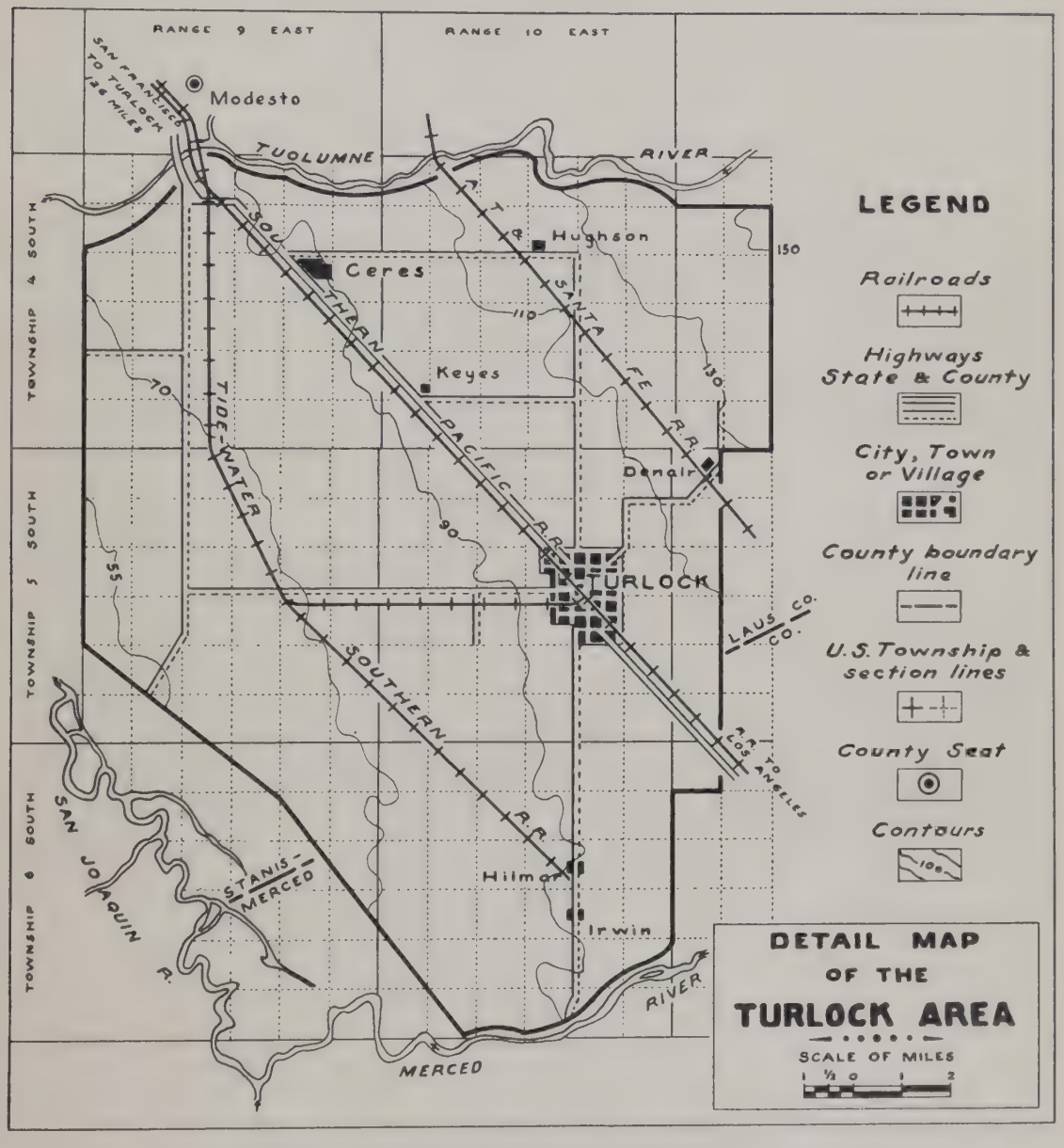


Fig. 2.—Detail map of the Turlock area.

sionally drop below freezing during the winter months and rise above 100° Fahrenheit in the summer for short periods only. Thus the area enjoys two rather distinct growing seasons: a period of about five months during the rainy season when crops favored by cool weather can be grown, such as barley, oats, peas, etc.; and a period of six to seven months when crops somewhat sensitive to cold but which thrive during warm weather, such as alfalfa, beans, corn, melons, sweet potatoes, tomatoes, and various fruits can be produced.

The soils of the area are mostly of a sandy nature, easily worked, fairly fertile, quickly irrigated, and mostly good to excellent in character although some localities are of limited agricultural importance because of the presence of hardpan or alkali. The soil survey of this area indicates eight principal soil types of the Fresno, Madera, San Joaquin, and Oakley series.[6]

The water table in certain localities tends to be high, traceable to excessive irrigation in the past, to impervious subsoils, inadequate drainage facilities, seepage from canals, and poor leveling and checking of

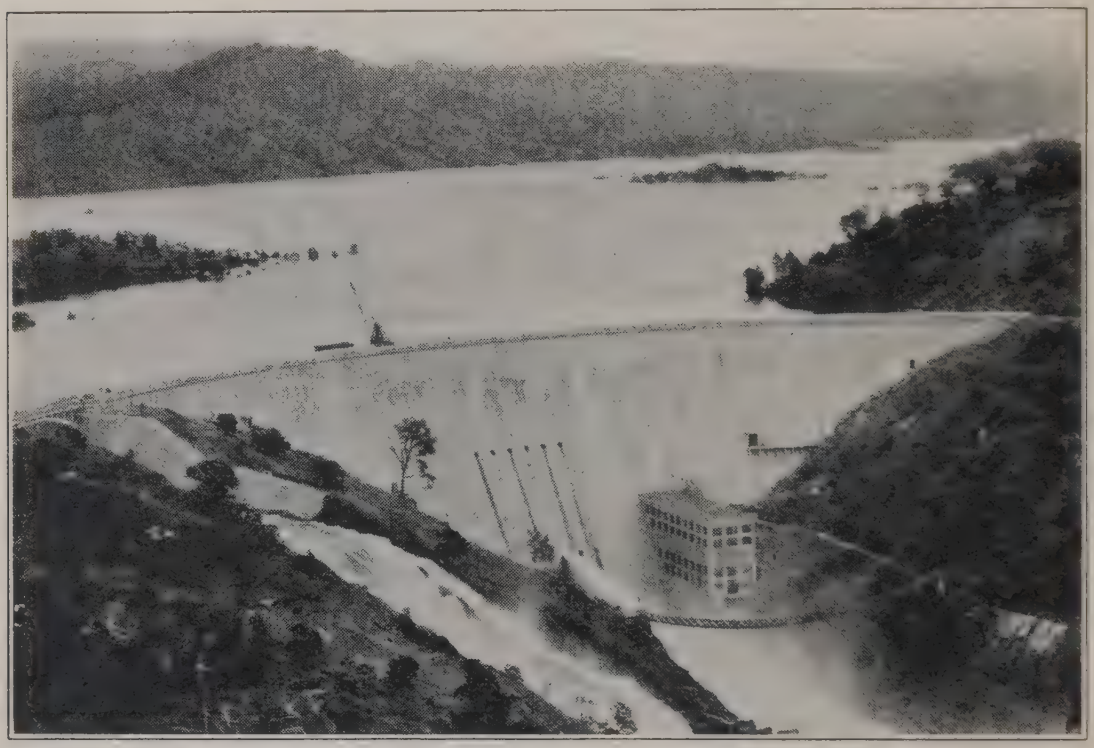


Fig. 3.—Don Pedro Dam Reservoir and Power House on the Tuolumne River, owned jointly by the Modesto and Turlock Irrigation Districts, provides for a gross storage of 291,300 acre-feet of water and a generating capacity of 30,000 kilowatts of electricity, of which the Turlock Irrigation District owns 68.46 per cent.

fields. This condition is being rectified by the installation of adequate drainage facilities in all parts of the area.

The area is essentially one of small, intensively cultivated farms. Nearly 75 per cent of the number of the farm holdings (totaling 3,390 farms in all) are from 10 to 40 acres in size. Over 40 per cent fall in the 11–20 acre group and nearly 33 per cent into the 21–40 acre group.

While the data were drawn from the Turlock area, conditions there are sufficiently typical of a large part of both the Sacramento and San

[6] Fully described in: Nelson, J. W., J. E. Guernsey, L. C. Holmes, and E. C. Eckman. Reconnaissance soil survey of the Lower San Joaquin Valley, California, pp. 1–157. Advance sheets of field operations of the U. S. Dept. Agr. Bureau of Soils, 1915.

Joaquin valleys so that the presentation is generally applicable to the irrigated areas of this part of the state after modifying for local differences. The investigations and analyses thus disclose facts and methods which can be utilized to advantage by many farmers and farm leaders in planning similar readjustments designed to increase the earning power of a large number of California farms.

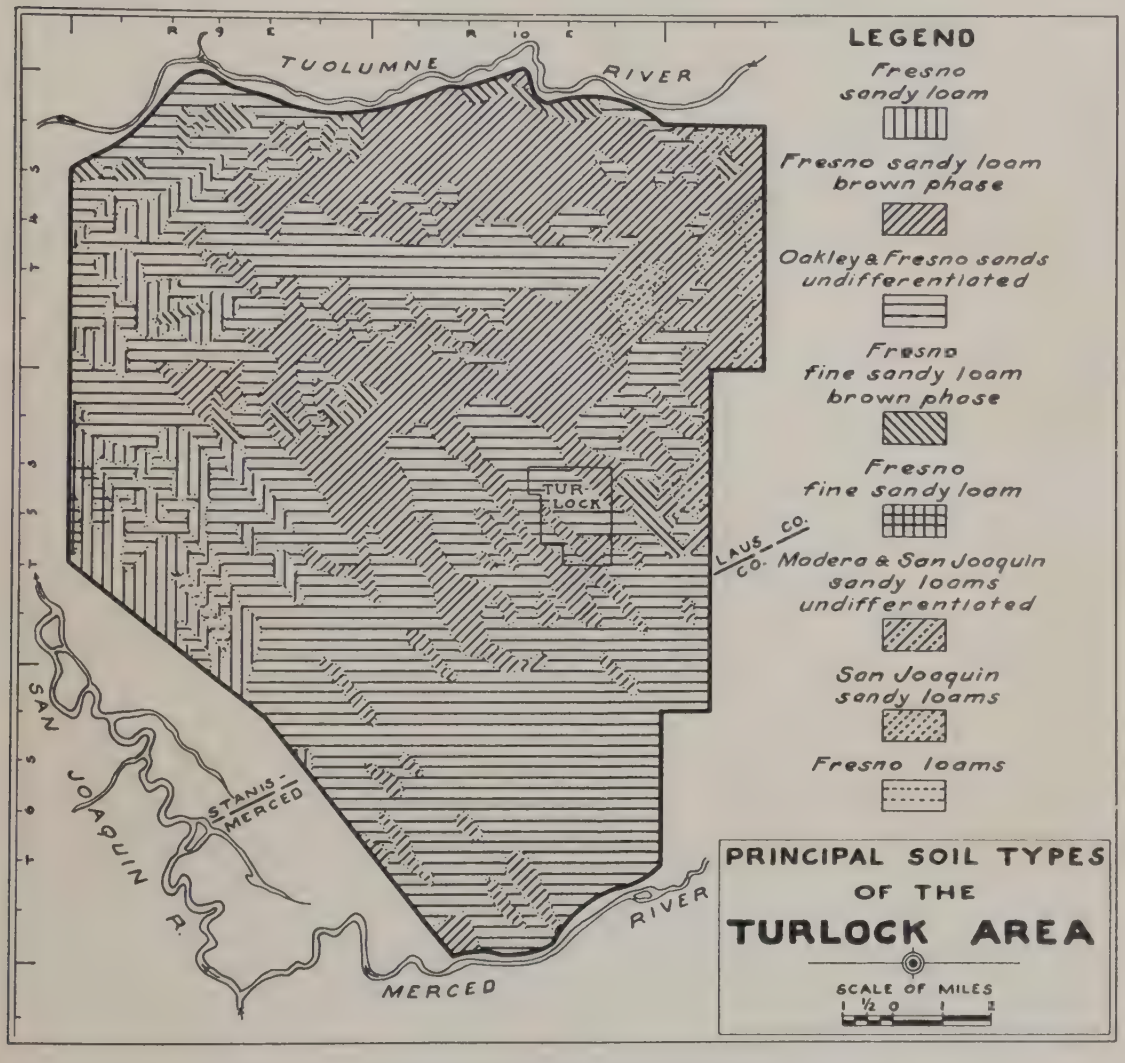


Fig. 4.—Principal soil types of the Turlock area.

COLLECTION OF BASIC DATA

A prolonged study was conducted in the Turlock area for the purpose of collecting the necessary data concerning sizes of farms; kinds, extent, and concentration of the more important commercial farm enterprises; yields; conditions affecting the amount of yields which are or can be obtained; nature and extent of farm practices customarily followed in the locality; prices paid farmers over a period of years by various agencies to whom the producers are in the habit of selling; production re-

quirements of each enterprise; costs of the items of expense involved in carrying on the farm business; and operators' ideas concerning the amount of net income needed to satisfy their financial requirements.

No attempt was made to evaluate the knowledge, skill, or physical capacity of the farm operators, nor was attention given to their experience, ages, social status, or similar matters.

The investigation thus included five of the six factors affecting farm earnings (e.g., size of farms, enterprises, yields, prices, and expenditures), but excludes the sixth (e.g., operator's ability).

Data on sizes of farms, yields, prices, necessary expenditures, and cost of the investment items are set forth in tables of the Appendix.

AGRICULTURE OF THE AREA

Agriculture of the Turlock area centers chiefly in the commercial production of field crops—alfalfa, beans, grain sorghums, and cereals; of fruits—apricots, grapes (raisin, table, and juice), and peaches; of truck crops—cantaloupes, melons (Casabas, Honey Balls, Honey Dews, Persians, watermelons), and sweet potatoes; minor acreages of almonds, figs, walnuts, berries, corn, peas, pumpkins, rice, spinach, and squash; and of livestock—dairy cattle, poultry, and some hogs.

The proportion of acreages devoted to different crops and enterprises varies from year to year. Table 1 gives the annual and average acreage of crops for the years 1927 to 1931 inclusive.

Although the agriculture of the area as a whole is diversified, there is evidence of a tendency for localized areas and individual farms to concentrate upon a relatively few tested enterprises. A brief description of such localization of enterprises follows.

Alfalfa.—Alfalfa is grown generally throughout the area as the principal legume for soil improvement and to produce feed for livestock. It is grown so extensively that it has averaged 30.0 per cent of the total irrigated acreage for the past 5 years. There is some tendency towards concentration of plantings in the western and southern portions.

Beans.—Beans, principally of the Blackeye variety, are grown generally throughout the area either as an early crop or as a second crop following winter truck crops or small grains. There is some tendency to concentrate early plantings in the northeastern and north central parts of the area and late plantings in the northwestern and west central sections.

TABLE 1

Annual and Average Acreages of Irrigated Crops in the Turlock Area, 1927–1931

Crop	1927	1928	1929	1930	1931	Average
Field crops:	*acres*	*acres*	*acres*	*acres*	*acres*	*acres*
Alfalfa	37,768	39,945	39,706	41,648	41,729	40,159
Beans*	27,018	20,029	26,139	31,825	26,168	26,236
Corn*	9,846	9,242	7,501	6,226	7,545	8,072
Cotton	——†	——†	——†	205	265	235
Grain	20,692	24,965	28,138	28,597	31,535	26,785
Rice	1,715	1,808	1,062	743	443	1,154
Tree fruits and nuts	11,484	11,132	9,458	9,683	8,895	10,130
Vines, grape	14,749	15,049	13,932	13,234	12,737	13,940
Truck crops:						
Cantaloupes	3,398	4,287	3,303	3,475	4,506	3,794
Melons*	3,334	3,678	4,290	4,079	3,083	3,693
(Casabas, Honey Dews, Honey Balls, Persians, etc.)						
Sweet potatoes	4,429	3,683	3,684	3,144	3,932	3,774
Watermelons	2,069	2,188	3,166	1,608	2,828	2,372
Pasture (irrigated)*	——†	——†	4,218	6,827	8,124	6,390
Garden	1,666	1,409	1,710	1,374	1,987	1,629
Miscellaneous*	3,984	5,588	1,815	199	2,143	2,746
Total acres irrigated	130,068	131,238	133,754	136,513	138,098	133,934

* Figures include second-crop plantings.

† Reported under "Miscellaneous."

Source of data: Office of Turlock Irrigation District.



Fig. 5.—Alfalfa is the mainstay of agriculture of the Turlock area. It is grown both for feed—hay and pasture—and for purposes of soil improvement to maintain or increase the crop-producing power of the land. This photograph is typical of the general aspect of the area.

Corn and Sorghums.—Maize, grain sorghums, and honey sorghums are grown generally throughout the area. Some smaller concentrations of plantings occur in the southwestern quarter of the area on soils of the Oakley and Fresno sands (undifferentiated) and on limited areas of the poorer phases of the Fresno sandy loams.

Small Grains.—The cereal crops—barley, oats, rye, and wheat—utilized as hay, grain, or pasture for livestock feeding, are grown generally throughout the area. In the northern section a larger portion of the lands are devoted to these winter crops than in the southern section, apparently because of the more general practice of double-cropping in the northern part of the area.

Rice growing is limited in extent and confined to a few relatively large holdings located along the western and southwestern borders of the area, principally on soils of the Fresno series. Soils selected for rice growing are underlain with an impervious subsoil or hardpan which makes possible the flooding required in rice production.

Tree Fruits.—Peaches, the main orchard crop, are principally grown in an L-shaped belt in the northeastern portion of the area, mainly on Fresno sandy loams (brown phase), but to some extent on Oakley and Fresno sands (undifferentiated). Apricots vie with peaches in the occupancy of this belt. Figs are grown in a restricted area south of and contiguous to the peach belt. Minor plantings of almonds, olives, prunes, and walnuts are scattered here and there throughout the peach belt.

Grapes.—Vineyards occur in various parts of the total area, with greatest concentration in the vicinity of the towns of Ceres and Keyes. The predominating soils utilized for vineyards are Oakley and Fresno sands (undifferentiated) and Fresno sandy loam (brown phase), yet grapes of various types and varieties are grown rather generally throughout the district.

Truck Crops.—Truck crops are grown principally in a rectangular belt roughly 7 miles long by 5 miles wide lying in the north central part of the area. Within this area are concentrated plantings of cantaloupes, Honey Dews and other melons, and sweet potatoes. The soil types are principally Oakley and Fresno sands (undifferentiated), and Fresno sandy loam (brown phase). In addition, scattered plantings are distributed generally throughout most of the area.

Over 70 per cent of the acreage planted to cantaloupes is confined to the east central portion of the area. The principal soil types utilized for cantaloupe production are Fresno sandy loams (brown phase) and Oakley and Fresno sands (undifferentiated).

Approximately 50 per cent of the melon plantings are to be found in the same general belt where concentration of cantaloupes occurs. The remainder of the crop is distributed more widely than cantaloupes, especially in the southern portion of the area. Since cantaloupes are more exacting in soil requirements, melons are usually planted on the less desirable lands or in a less favorable place in the crop rotation.

Watermelons are grown to a limited extent in all parts of the area. The heaviest plantings occur in the general vicinity of Keyes and Turlock. The total acreage of watermelons is made up of numerous small plantings; large acreages are practically never planted by individual growers. The lighter phases of the Fresno loams and the Oakley and Fresno sands (undifferentiated) are preferred for this crop.

Sweet-potato production is mainly confined to the eastern half of the area with a tendency towards some concentration in the north central and southern portions of the truck-crops belt. Small, scattered plantings occur elsewhere throughout the area, the total of which, however,



Fig. 6.—Turlock is famed for its production of cantaloupes of excellent quality. This picture, taken in midseason, depicts the method of irrigating this crop.

amounts to less than 10 per cent of the entire acreage. Since the soil and moisture requirements of this crop are rather exacting, their production is confined to the lighter phases of the Fresno sandy loams and to the Oakley and Fresno sands (undifferentiated) especially if subirrigation is sufficient to eliminate or reduce to a minimum the necessity for surface irrigation.

Dairying.—Dairying is conducted principally in the western and southern portions—a section involving about one-half of the acreage of the entire area. Generally this portion embraces the less desirable lands of the district, less desirable because of the prevailing soil types, presence of alkali, roughness of topography, and accumulated damage from high water table. Alfalfa, barley, oats, rye, maize, grain sorghums, and Sudan grass grown primarily for feed, vie with cash crops, principally

beans and melons, although other field and truck crops are occasionally utilized. Some of the land along the western boundary of the area, unfit for alfalfa or other field crops because of uneven topography or alkalinity, is utilized as natural pasture. The predominating soil types of this section are Oakley and Fresno sands (undifferentiated) and the sandy loam, fine sandy loam, and loams of the Fresno series.

Poultry Raising.—Poultry raising for egg production is carried on in this area principally as a complementary enterprise on the smaller-sized farms. There are a few specialized poultry farms with relatively large flocks, but in general, the poultry industry is made up of numerous small flocks.

Turkeys are raised by a few growers but this industry at present is relatively unimportant.

Overlapping of Belts.—The tendency towards concentration of enterprises is noted above. The boundaries of the different belts are, however, neither clearly defined nor wholly inclusive. Thus, though the tendency is for dairying to be concentrated on the west side, and for fruits and truck crops to be confined to the east side, exceptions occur throughout the entire area. Some dairies are located on the east side, and limited plantings of fruit and truck crops occur on the west side. The merging of one type of agriculture into another tends to take place in such a manner that a definite delineation of crop belts cannot be given.

From material collected during the course of the investigation, no significant differences were discerned in the current farming practices employed by growers in the different crop belts. With the exception of minor variations for local conditions the methods followed by farmers in this community are in close accord with the generally recognized and accepted practices commonly used in the production of irrigated crops in the interior valley of California. A brief description of the cropping practices for each of the more important crops is given in connection with the discussion of "calendars of operations" in tables 4, 5, and 6, and in other sections that follow.

METHOD OF TESTING PLANS OF FARM ORGANIZATIONS

The plan of procedure employed in the testing of farm organizations involves six major steps described somewhat in detail as follows:

1. An account of the type of business, total acreage, net acreage in crops, utilization (e.g., kinds of enterprises, acreages of crops, numbers of livestock), farming practices, yields and disposition of the products.

2. A list of the necessary investment items (land, buildings and other structures, motive power, implements, machinery, harness, tools, departmental equipment, etc.) and their costs or value.

3. A statement of kinds and amounts of products obtained, reported as gross, reserved for home or farm use, and net for sale. In the analysis which follows, this information is given in quantities so that the income in money can be determined at any time by applying pertinent price data.

4. Preparation of a calendar of operations. This is a graphic tabulation which sets forth the number of days available for field and other work, the enterprises to be cared for, the operations to be performed, the equipment to be used, the time when the work must be done, the rate of work, the amount which can be done by the operator, and the total requirements for each and all operations. In determining the labor requirements of these different farms only work of a directly productive nature has been included. It is fully recognized, however, that every farmer faces numerous additional odd jobs, such as building or repairing fences, painting or repairing buildings, adjusting or repairing implements, maintaining roads or lanes, and the routine tasks of feeding and caring for work animals. This type of labor is classed as "chores" and the amount performed depends on the available time for such tasks, as well as by the inclination and ability of the operator to perform them. Much of this labor, by proper planning, can be done without interfering with the major productive tasks, and as a rule does not amount to more than about 10 per cent of the total productive labor. In the calendars of operations prepared for these farms, this item of chores has been ignored.

In order to determine the number of days usually available for "aboveground" work and for "soil work" in the Turlock area, a tabulation from the daily weather reports of the Weather Bureau of the United States Department of Agriculture over a 5-year period was made of the number of days each month in which the rainfall amounted to 0.25 of an inch or more. This amount of rainfall is deemed sufficient to

stop field work for a period of 3 days, until the soil dries sufficiently to permit cultural operations to be resumed. Figured on a 26-day month the usual number of days available for "aboveground" and "soil work" are as follows:

Month	Aboveground work	Soil work
January	21	14
February	19	11
March	24	21
April	20	18
May	25	23
June	26	26
July	26	26
August	26	26
September	25	25
October	24	22
November	22	17
December	20	16
Total	278	245

Considerable variation occurs in the amount and time of precipitation in any given month over a period of years. Although the figures presented in the above tabulation are only indicative of what may usually be expected, they are sufficiently representative to serve our purpose.

In connection with the calendar of operations an inquiry was made into the degree of efficiency of the operator's labor. Likewise a test was made of the degree of efficiency in the use of farm-owned work animals. Too much stress must not, however, be attached to the findings regarding the degree of efficiency in the use of the operator's labor nor of farm work animals. The final test is the amount of net income which a given plan will provide. If a certain plan results in a relatively high net income irrespective of a low degree of efficiency in the use of the operator's labor or of his work animals, the operator may be satisfield to continue with his present form of organization. But if the income is unsatisfactory and his farming operations show wide gaps in the seasonal program and provide a relatively small amount of productive labor then a study of additional enterprises may be very much in order. The calendar of operations provides an easy way for testing new plans in order to note the effect upon the business program and upon the final earnings.

5. A statement of production and maintenance outlays required to grow, harvest, and sell crops, care for animals, produce milk and eggs, and keep up the farm in condition for continued production. These expenditures, so far as practical, are reported in terms of quantities (e.g.,

hours of hired labor, pounds of seed or feed, numbers of sacks, boxes, or other market containers, etc.).

6. As a final step, for purposes of illustration and greater clarity, a financial statement is drawn up, to show the value of the production in dollars and cents, to show the cost in money of the various expenditures, and to indicate the resulting net farm income. Although a review of the findings is easier when the physical quantities are converted into money terms, yet the changing prices received by producers and the changing costs of the various expenditures require that revisions be made from time to time in order that the financial statements shall be truly representative. This can be done by anyone interested since the tabular data are presented in comprehensive detail.

EXPLANATION OF TERMS

In order that the reader may correctly interpret the results of the analyses which follow, an explanation is made of the more important terms used which are not entirely self-explanatory.

Yield: The total usable or marketable production based on (*a*) the unit; (*b*) the enterprise; or (*c*) the farm.

Selling price: Selling price is the price received by producers for products of the farm prepared for market in accordance with the custom prevailing in the community. Commodities produced and retained for consumption on the farm are valued at *farm price* (i.e., the selling price less cost of preparing for market and delivering to the primary buyer).

Gross income: Gross income is the total gross receipts obtained from the amount of marketable products. It is the result of multiplying yield of marketable product by the selling price of the commodity.

Expenses: Expenses are made up of (*a*) cash expenditures, (*b*) depreciation, and (*c*) mortality of livestock. Expenditures include all cash outlays for such items as hired labor, materials (purchased for use in connection with crops and livestock production), repair parts, shop materials, taxes, and insurance. Depreciation is a charge prorated annually to cover replacement of equipment and improvements rendered useless through wearing out, obsolescence, or destruction from any cause. Mortality of livestock is a charge prorated annually to cover losses incurred through the death of livestock resulting from accident, sickness, or condemnation on account of disease.

Net income: Net income is the difference between gross income and expenses as described above. According to this definition no allowance is made for any work performed by the operator nor is a charge included to cover interest on the value of land, any and all improvements, livestock, or equipment irrespective of whether or not interest must be paid

on account of mortgages, operating loans, or other financial obligations incurred for the conduct of the farm business. The terms *net income* and *net farm income* are used interchangeably in this publication.

Viewed in this way the operator must look to net income for reimbursement for his services, both manual and managerial, for interest on his investment, for means of discharging his financial obligations, for creating a reserve for possible emergencies or contingencies, and for any profits.

TESTS OF SELECTED TYPES OF FARM ORGANIZATIONS

From the wealth of data resulting from the investigations, four types of farms were selected for detailed testing, primarily devoted to (*a*) field crops, (*b*) fruits, (*c*) truck crops, and (*d*) dairying respectively. Hypothetical set-ups based on crop rotations and farming practices followed by the more experienced growers of the area were made for 40-acre farm units.

Each of these four types of farms were subjected to detailed analysis to show the earning power of the present organization under stated conditions of prices and costs.

Following the determination of present earning capacity, certain alternative plans and conditions for each farm were then tested to determine the effect upon earning power resulting from changes made in the existing plan. Alternative plans for the field-crops farm were tested under conditions of (*a*) changes in the selling prices of products; (*b*) an increase in yields; (*c*) an increase in the size of farm; (*d*) addition of a 10-cow dairy; and (*e*) addition of a 500-fowl poultry plant. The fruit farm was likewise tested under conditions of changes in the selling prices of farm products, an increase in yields, and the addition of a 500-fowl poultry plant. Further tests were made to compare the returns derived from drying fruit instead of selling it fresh and to note the results obtained from a 20-acre unit as compared with a 40-acre farm. Comments on the use of funds, reserved for depreciation and maintenance of farm equipment, for family living or other purposes are discussed in some detail. The truck-crops farm was tested to determine the prices which must be received in order to provide a net farm income of $1,800, to note the effects of increasing yields, and to compare the relative incomes when sweet potatoes were substituted for cantaloupes. The effect of increasing the size of farm and the possibility of adding a livestock enterprise are subjects of comment. The dairy farm was tested to determine the effect upon earnings of larger production per cow, changes in selling prices of dairy products, and of increasing crop yields. Comments are made on the effect on net income resulting from sale of manure and from reducing overhead expenses.

The financial statement prepared in connection with each plan shows the net farm income. The findings are specifically applicable to conditions reflecting prices and costs as used in the calculations. Revisions can, however, be made with other price data and other costs when such revisions are in order.

ANALYSIS AND FINDINGS OF A 40-ACRE FIELD-CROPS FARM

On the 40-acre field-crops farm selected for testing, 37½ acres are used for a 9-year rotation plan consisting of alfalfa, 6 years; barley hay and blackeye beans, double-cropped, 2 years; grain sorghum, 1 year. The balance of the acreage is utilized by the farmstead, ditches, and lanes. The cropping program provides for plowing up one-half of the old alfalfa every third year to be followed on successive years by crops of barley hay, beans, and grain sorghum. A corresponding acreage is seeded to new alfalfa every third year on the land previously planted to grain sorghum. Three fields of 12½ acres each are required for this plan which, when in full and regular operation, will provide for a sequence of plantings as shown in table 2.

TABLE 2

ROTATION OF CROPS ON A 40-ACRE FIELD-CROPS FARM

Year of rotation	Field 1	Field 2	Field 3
1	New alfalfa	Alfalfa	Barley hay and beans
2	Alfalfa	Alfalfa	Barley hay and beans
3	Alfalfa	Alfalfa	Grain sorghum
4	Alfalfa	Barley hay and beans	New alfalfa
5	Alfalfa	Barley hay and beans	Alfalfa
6	Alfalfa	Grain sorghum	Alfalfa
7	Barley hay and beans	New alfalfa	Alfalfa
8	Barley hay and beans	Alfalfa	Alfalfa
9	Grain sorghum	Alfalfa	Alfalfa

Field 1 shows the standard rotation operating in regular order. Field 2 and Field 3 indicate the place of each field in the rotation under conditions requiring the replanting of a portion of the alfalfa every third year.

The crop acreages during each of the first 3 years of the rotation are given in table 3. Thereafter, as long as the planting program described above is followed, the acreage of crops for each successive 3-year period are the same as for the first 3 years of the rotation. As each 3-year cycle

is a repetition of the first, it is necessary to test only 1 of these 3-year periods to determine the efficiency and financial possibilities of this cropping program.

TABLE 3

CROP ACREAGES FOR EACH OF THE 3 TYPICAL YEARS OF THE ROTATION ON A 40-ACRE FIELD-CROPS FARM

Crop	Order of rotation		
	First year	Second year	Third year
	acres	*acres*	*acres*
Alfalfa, new	12.5	0.0	0.0
Alfalfa, mature	12.5	25.0	25.0
Barley hay, Beans } double-cropped	12.5	12.5	0.0
Grain sorghum	0.0	0.0	12.5

Attention should be called to the fact that cropping practices vary from farm to farm, because of differences in physical factors (i.e., soil types, topography, irrigation facilities, etc.), in sizes of farms, in types and sizes of equipment available, and differences of opinion in the minds of operators as to what constitutes the best practice. The basic plan as used here is, however, indicative of the general plan followed by the more successful farmers of the area.

Farming Practices.—Methods employed in the production of these crops are in accord with the customary procedure followed in the community.

The mature alfalfa is annually renovated during the dormant season with a spring-tooth harrow. Cuttings, six in number, begin early in April and continue at intervals of four to six weeks into October. An irrigation is supplied between cuttings, a total of five applications being given during the season. The cured hay crop is either put in the barn for future feeding to work animals or else stacked, baled, and subsequently sold. If there is sufficient demand the first cutting may be sold in the shock but the practice is not sufficiently general to warrant its inclusion. The baled hay, when sold, is delivered by the grower to a warehouse or shipping point.

Barley for hay is broadcast and covered by a spike-tooth harrowing sometime during October, November, or December on land previously irrigated, plowed, and harrowed. Mowing, raking, shocking, and curing takes place during the latter part of April or the early part of May. The cured product is then placed in the barn for feeding to work animals, to be supplemented by sufficient alfalfa hay to take care of the total feeding needs.

Blackeye beans are planted immediately following the harvest of the barley-hay crop. The land is prepared by irrigating, plowing, and harrowing. Planting is done with a 2-row planter in rows 3 feet apart. The growing crop is given three cultivations with a riding cultivator, followed by a thinning, hoeing, and one crop irrigation. Harvesting takes place in September and October; the rows are split with a 1-horse bean row splitter, then cut with a bean sled, shocked, cured in the shock, and threshed under contract. The threshed beans are placed in sacks containing 90 pounds net and hauled to a warehouse for cleaning, fumigating, and storing until sold.

The grain sorghum is grown as a single crop, on land plowed, harrowed three times (once with a spring-tooth harrow and twice with a spike-tooth harrow), and then planted with a 2-row planter, in rows spaced 3 feet apart. Planting takes places in April or May. The growing crop is given a spike-tooth harrowing (with the teeth inclined back) while the plants are small, followed at later dates by two cultivations between the rows (once with a 2-row riding cultivator and once with a single-row cultivator). One crop irrigation is applied usually in July. Harvesting, in September or October, consists of cutting off the heads by hand, tossing onto a wagon, hauling from the field, piling in a convenient place and allowing heads to cure before threshing. Threshing is done from the pile and under contract. The threshed grain is placed in sacks holding from 130 to 160 pounds, hauled to a warehouse, and stored pending sale.

Seeding the sorghum land to alfalfa takes place the next spring following the growing of sorghum. The field is first rechecked and releveled within the checks, and the land plowed, harrowed, and cross-harrowed until it is in shape for seeding. The seed is sown broadcast in late February or early March. A clipping with the mower is usually given in April or May to discourage weeds. The first cutting for hay is made in June, and three additional cuttings follow at intervals of from four to six weeks. Four irrigations are given to the growing crops, one after the clipping and one between each two cuttings. The harvested hay is handled as already described for mature alfalfa.

Yields.—The yields of crops used in testing the physical efficiency and the financial returns obtainable from this farming program, under stated conditions of costs and selling prices, are:

Alfalfa, mature stand, 5 tons per acre per season
Alfalfa, year of planting, 2 tons per acre
Barley hay, 2 tons per acre
Blackeye beans, 9 sacks of 90 pounds net per acre
Grain sorghum, 1,800 pounds of threshed grain per acre

TABLE 4

CALENDAR OF OPERATIONS FOR A 40-ACRE FIELD-CROPS FARM FOR FIRST YEAR OF ROTATION

(Mature alfalfa, 12½ acres; new alfalfa, 12½ acres; barley hay and beans, double-cropped, 12½ acres)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Barley hay:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Harrowing (2 ways)	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5			
	Seeding	2	2	Wagon and broadcaster	30.0 acres	1.0	1.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	16.2 acres	2.0	1.0			
	Total					29.5	12.0	17	11.5	0.5
December	Alfalfa (new seeding):									
	Disking	1	2	4-ft. single disk	6.5 acres	4.0	2.0			
	Plowing levees	1	2	12-in. plow	13.0 acres	2.0	1.0			
	Checking and leveling	1	4	5-ft. Fresno scraper	5.0 acres	10.0*	2.5			
	Plank dragging	1	2	8-ft. plank drag	6.5 acres	4.0	2.0			
	Setting outlet boxes (2 per acre)	2			4.0 acres	0.0	6.0			
	Total					20.0*	13.5	16	10.5	3.0
January	Alfalfa (mature):									
	Renovating	1	3	6-ft. spring-tooth harrow	4.1 acres	9.0	3.0			
	Alfalfa (new seeding):									
	Spreading manure (8 tons per acre)	1	2	Wagon	8 tons	25.0	12.5			
	Total					34.0	15.5	14	15.5	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Alfalfa (new seeding):									
	Plowing (late in month)	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Total					23.5	8.5	11	8.5	0.0

March	Alfalfa (new seeding):								
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.8 acres	9.0	3.0		
	Seeding	2	2	Wagon and broadcaster	24.3 acres	1 0	1.0		
	Harrowing	1	2	10-ft. spike-tooth harrow	13.5 acres	2.0	1.0		
	Total					12.0	5.0	21	4.5	0.5
April	Alfalfa (mature), first cutting:								
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5		
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0		
	Shocking	1		Pitchfork	10 tons	0.0	0.5		
	Hauling and storing in barn	2	2	Wagon	10 tons	1.5	2.0		
	Irrigating	2		Shovels	18.0 acres	0.0	2.0		
	Barley hay:								
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5		
	Raking and bunching	1	2	12-ft. rake	13.0 acres	2.0	1.0		
	Shocking	1		Pitchfork	18.0 tons	0.0	1.5		
	Alfalfa (new seeding):								
	Clipping	1	2	5-ft. mower	8.0 acres	3.0	1.5		
	Irrigating	2		Shovels	18.0 acres	0.0	2.0		
	Total					14.5	14.5	18	11.5	3.0
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5		
	Alfalfa (mature), second cutting:								
	Mowing	1	2	5-ft. mower	8.0 acres	3 0	1.5		
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0		
	Shocking	1		Pitchfork	10 tons	0.0	1 0		
	Hauling and stacking	2	2	Wagon	10 tons	3.0	3.0		
	Irrigating	2		Shovels	18.0 acres	0.0	2.0		
	Barley hay:								
	Hauling and stacking	2	2	Wagon	10 tons	5.0	5 0		
	Blackeye Beans:								
	Irrigating	2		Shovels	12.0 acres	0.0	2.0		
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5		
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.0 acres	7.5	2.5		

(*Concluded on p. 24*)

* Includes rental of 1 horse for 3 days for scraper work.

TABLE 4—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
May (*concluded*)	Alfalfa (new seeding), first cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	0.5			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Total					47.0	28 5	23	22.5	6.0
June	Alfalfa (mature), third cutting (same as second cutting):					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Blackeye beans:									
	Harrowing (2 ways)	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5			
	Planting	1	2	2-row bean planter	8.1 acres	3.0	1.5			
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5			
	Hoeing and thinning	1		Hoe	1.0 acre	0.0	12.5			
	Alfalfa (new seeding):									
	Hauling and stacking	2	2	Wagon	10 tons	1.0	1.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Total					19.0	29.0	26	25.0	4.0
July	Alfalfa (mature), fourth cutting (late in month; same as second cutting):					8 0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Blackeye beans:									
	Irrigating	2		Shovels	12.0 acres	0.0	2.0			
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5			
	Alfalfa (new seeding), second cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			

	Shocking	1		Pitchfork	10 tons	0.0	1.0			
	Hauling and stacking	2	2	Wagon	10 tons	2.0	2.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Total					18.0	19.5	26	13.5	6.0
August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Blackeye beans:									
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5			
	Alfalfa (new seeding), third cutting (same as second cutting):					7.0	5.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Total					11.0	9.5	26	7.0	2.5
September	Alfalfa (mature), fifth cutting (same as second cutting):					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Blackeye beans:									
	Splitting rows	1	1	Bean row splitter	4.8 acres	2.5	2.5			
	Cutting vines	1	2	2-row sled cutter	9.0 acres	3.0	1.5			
	Bunching vines	1		Pitchfork	2.5 acres	0.0	5.0			
	Alfalfa (new seeding), fourth cutting (same as first cutting):					6.0	4.0			
	Total					20.5	22.0	25	16.0	6.0
October	Alfalfa (mature), sixth cutting (same as first cutting):					6.5	5.0			
	Blackeye beans:									
	Threshing	4		Pitchforks	225 sacks	0.0	2.0			
	Hauling sacks from field	1	2	Wagon	240 sacks	1.0	0.5			
	Alfalfa (new seeding):									
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Total					7.5	9.5	22	6.0	3.5
	Total for year					256.5*	187.0	245	152.0	35.0

* Includes rental of 1 horse for 3 days for scraper work.

TABLE 5

CALENDAR OF OPERATIONS FOR A 40-ACRE FIELD-CROPS FARM FOR SECOND YEAR OF ROTATION

(Mature alfalfa, 25 acres; barley hay and beans, double-cropped, 12½ acres)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Barley hay:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Harrowing (2 ways)	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5			
	Seeding	2	2	Wagon and broadcaster	30.0 acres	1.0	1.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	16.2 acres	2.0	1.0			
	Total					29.5	12.0	17	11.5	0.5
December	Total					0.0	0.0	16	0.0	0.0
January	Alfalfa (mature):									
	Renovating	1	3	6-ft. spring-tooth harrow	4.1 acres	18.0	6.0			
	Total					18.0	6.0	14	6.0	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Total					4.0	2.0	11	2.0	0.0
March	Total					0.0	0.0	21	0.0	0.0
April	Alfalfa (mature), first cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	6.0	3.0			
	Raking	1	2	12-ft. rake	13.0 acres	4.0	2.0			
	Shocking	1		Pitchfork	10 tons	0.0	1.5			
	Hauling and stacking	2	2	Wagon	10 tons	3.0	3.0			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			

	Barley hay:								
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5		
	Raking and bunching	1	2	12-ft. rake	13.0 acres	2.0	1.0		
	Shocking	1		Pitchfork	18 tons	0.0	1.5		
	Total					18.0	16.5	18	13.5	3.0
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5		
	Alfalfa (mature), second cutting:								
	Mowing	1	2	5-ft. mower	8.0 acres	6.0	3.0		
	Raking	1	2	12-ft. rake	13.0 acres	4.0	2.0		
	Shocking	1		Pitchfork	10 tons	0.0	2.5		
	Hauling and stacking	2	2	Wagon	10 tons	5.0	5.0		
	Irrigating	2		Shovels	18.0 acres	0.0	3.0		
	Barley hay:								
	Hauling and storing in barn	2	2	Wagon	10 tons	5.0	5.0		
	Blackeye beans:								
	Irrigating	2		Shovels	12.0 acres	0.0	2.0		
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5		
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.9 acres	7.5	2.5		
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5		
	Total					49.0	32.5	23	23.5	9.0
June	Alfalfa (mature), third cutting (same as second cutting):					15.0	12.5		
	Irrigating	2		Shovels	18.0 acres	0.0	3.0		
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5		
	Blackeye beans:								
	Harrowing (2 ways)	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5		
	Planting	1	2	2-row bean planter	8.1 acres	3.0	1.5		
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5		
	Hoeing and thinning	1		Hoe	1.0 acre	0.0	12 5		
	Total					25.0	33.0	26	26.5	6.5

(*Concluded on p. 28*)

TABLE 5—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
July	Alfalfa (mature), fourth cutting (same as second cutting):					15.0	12.5			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Blackeye beans:									
	Irrigating	2		Shovels	12.0 acres	0.0	2.0			
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5			
	Total					18.0	19.0	26	14.0	5.0
August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Blackeye beans:									
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5			
	Total					4.0	2.0	26	2.0	0.0
September	Alfalfa (mature), fifth cutting (same as second cutting):					15.0	12.5			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Blackeye beans:									
	Splitting rows	1	1	Bean row splitter	4.8 acres	2.5	2.5			
	Cutting vines	1	2	2-row sled cutter	9.0 acres	3.0	1.5			
	Bunching vines	1		Pitchfork	2.5 acres	0.0	5.0			
	Total					21.5	25.0	25	17.5	7.5
October	Alfalfa (mature), sixth cutting (same as first cutting):					13.0	9.5			
	Blackeye beans:									
	Threshing	4		Pitchfork	225 sacks	0.0	2.0			
	Hauling sacks from field	1	2	Wagon	240 sacks	1.0	0.5			
	Total					14.0	12.0	22	9.0	3.0
	Total for year					201.0	160.0	245	125.5	34.5

TABLE 6

Calendar of Operations for a 40-Acre Field-Crops Farm for Third Year of Rotation

(Mature alfalfa, 25 acres; grain sorghum, 12½ acres)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Total					4.0	2.0	17	2.0	0.0
December	Total					0.0	0.0	16	0.0	0.0
January	Alfalfa (mature):									
	Renovating	1	3	6-ft. spring-tooth harrow	4.1 acres	18.0	6.0			
	Total					18.0	6.0	14	6.0	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Grain sorghum:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Total					23.5	8.5	11	8.5	0.0
March	Grain sorghum:									
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.8 acres	7.5	2.5			
	Harrowing (2 ways)	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5			
	Total					10.5	4.0	21	4.0	0 0

(*Continued on p. 30*)

TABLE 6—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
April	Alfalfa (mature), first cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	6.0	3.0			
	Raking	1	2	12-ft. rake	13.0 acres	4.0	2.0			
	Shocking	1		Pitchfork	10 tons	0.0	1.5			
	Hauling and stacking	2	2	Wagon	10 tons	3.0	3.0			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Grain sorghum:									
	Harrowing (2 ways)	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5			
	Planting	1	2	2-row planter	8.1 acres	3.0	1.5			
	Cultivating	1	2	10-ft. spike-tooth harrow	13.5 acres	2.0	1.0			
	Total					21.0	16.5	18	13.5	3.0
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature), second cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	6.0	3.0			
	Raking	1	2	12-ft. rake	13.0 acres	4.0	2.0			
	Shocking	1		Pitchfork	10 tons	0.0	2.5			
	Hauling and stacking	2	2	Wagon	10 tons	5.0	5.0			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Grain sorghum:									
	Cultivating	1	2	Riding cultivator	8.1 acres	3.0	1.5			
	Total					20.0	18.0	23	14.0	4.0
June	Alfalfa (mature), third cutting (same as second cutting):					15.0	12.5			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Grain sorghum:									
	Cultivating	1	1	Walking cultivator	4.0 acres	3.0	3.0			
	Total					19.0	19.0	26	15.0	4.0

July	Alfalfa (mature), fourth cutting (same as second cutting):									
	Irrigating	2		Shovels	18.0 acres	15.0 0.0	12.5 3.0			
	Grain sorghum:									
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Total					15.0	17.5	26	12.5	5.0
August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Grain sorghum:									
	Cutting heads and hauling (one-half of acreage)	1	2	Wagon	1 ton	11.0	5.5			
	Total					12.0	6.0	26	6.0	0.0
September	Alfalfa (mature), fifth cutting (same as second cutting):									
	Irrigating	2		Shovels	18.0 acres	15.0 0.0	12 5 3.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Grain sorghum:									
	Cutting heads and hauling (one-half of acreage)	1	2	Wagon	1 ton	12.0	6.0			
	Threshing	4		Pitchforks	900 sacks	0.0	1.5			
	Total					28.0	23.5	25	18.5	5.0
October	Alfalfa (mature), sixth cutting (same as first cutting):					13.0	9.5			
	Total					13.0	9.5	22	8.0	1.5
	Total for year					184.0	130.5	245	108.0	22.5

THE CALENDAR OF OPERATIONS

The calendar of operations for the 3 years of different cropping is given in detail in tables 4, 5, and 6. Chores, repair jobs, and similar routine work is not included, since our interest centers primarily in the major income-producing activities. If the time spent on chores is added, naturally the efficiency in use of the operator's time will be increased. The yearly total man and horse-labor requirements for each of the 3 typical years of the rotation are summarized in table 7.

TABLE 7

MAN AND HORSE-LABOR REQUIREMENTS ON A 40-ACRE FIELD-CROPS FARM

Order of rotation*	Man labor					Horse labor				
	Total required	By operator	Operator's efficiency†	Hired	Per cent hired	Total required	By farm owned horses	Efficiency of farm owned horses‡	Hired	Per cent hired
	man days	*man days*	*per cent*	*man days*	*per cent*	*horse days*	*horse days*	*per cent*	*horse days*	*per cent*
First year	187.0	152.0	50.7	35.0	18.7	256.5	253.5	34.5	3.0	1.2
Second year	160.0	125.5	41.8	34.5	21.6	201.0	201.0	27.3	0.0	0.0
Third year	130.5	108.0	36.0	22.5	17.2	184.0	184.0	25.0	0.0	0.0

* Acreages of crops for each year of rotation given in table 3.

† Based on 245 days a year available for field work.

‡ 245 total days available for field work. Horse efficiency based on 735 days, total for 3 horses.

These summarized figures are enlightening. The total number of productive days work for the operator—ranging from 108 to 152 days annually and averaging, for the 3-year period, 128½ days a year—is hardly representative of a high degree of efficiency in the use of the operator's time, when it is considered that an average of approximately 245 days each year are available for field work. An average of 128½ days of work a year based on a 245-work-day year constitutes an efficiency in use of the operator's time of only 52.4 per cent.

Extra labor is needed only at intervals and for periods of but ½ to 3 days at a time. This means that no regular men can be employed and that reliance must be placed either upon the hiring of an occasional man on a day basis whenever a need arises or upon exchanging labor with a neighboring farmer.

A low degree of efficiency is likewise recorded in the use of work animals. Keeping horses that could be used 245 days out of the year and employing them only one-fourth to one-third of this time is bound to result in a high daily cost for the time when they are gainfully employed.

The calendar indicates that this cropping plan, the operations of which are spread fairly well over the year, results in no protracted periods when either no work occurs or when the work piles up to a burdensome extent. One of the 3 years, because of the reseeding to alfalfa, provides more work for the operator than do the succeeding 2 years when his work is confined to mature alfalfa, barley hay, and Blackeye beans, or to mature alfalfa and grain sorghum. During the year when alfalfa is being reestablished, May and June are busy months, but the rest of the year, as an inspection of the calendar will show, provides spare time for additional work. The other 2 years allow even more time. This is brought out more emphatically in table 8.

TABLE 8

Number of Days Operator of a 40-Acre Field-Crops Farm Has Available for Additional Work*

Month	First year		Second year		Third year	
	Total†	For soil work‡	Total†	For soil work‡	Total †	For soil work‡
	1	*2*	*3*	*4*	*5*	*6*
November	14 5	5.5	14.5	5.5	24.0	15.0
December	15.5	5.5	26.0	16.0	26.0	16.0
January	10.5	1.5	20.0	8.0	20.0	8.0
February	15.5	2.5	22.0	9.0	15.5	2.5
March	21.5	16.5	26.0	21.0	22.0	17.0
April	14 5	7.0	12.5	9.5	12.5	4.5
May	3.5	0.5	2.5	2.5	12.0	9.0
June	1.0	1.0	0.0	0.0	11.0	11.0
July	12.5	12.5	12.0	12.0	13 5	13.5
August	19 0	19.0	24.0	24.5	20.0	20.0
September	10.0	9.0	8.5	7.5	7.5	6.5
October	20.0	14.0	17.0	13.5	18.0	14.0
Total	158.0	94.5	185.0	129.0	202.0	137.0

* Labor requirements of this cropping plan are based on a 9-hour work day.

† Time available for additional work is the difference between the time needed for carrying on the present organization and a 26-day month, except February, which is a 24-day month. It might be used for work away from the farm, for types of work not limited by climatic conditions, such as the handling of livestock, pruning of trees, etc., or for soil work to the extent given in columns 2, 4, and 6.

‡ Of the total number of days available for additional work the figures in columns 2, 4, and 6 show the amount each month which can be used in performing additional soil operations under average weather conditions.

The data given in table 8 is not necessarily a criticism of the present form of organization. The primary purpose of this table is to point out to the operator the possibilities for making more efficient use of his time by undertaking part-time employment, provided it can be obtained, by reorganizing his farming program, or by increasing the acreage farmed, in order to increase his income.

FINANCIAL RESULTS

The final test of any proposed farm plan is the financial return which it is likely to produce. To demonstrate the procedure to be followed in calculating the net income obtainable from the cropping program previously described for this 40-acre farm, investment, production, and financial statements, showing in detail the computation of gross income, expenses, and net incomes, under stated conditions of prices and costs, have been prepared.

Investment Items.—An inventory of the physical properties of this 40-acre field-crops farm as a fully equipped operating unit, includes the following list of investment items:

Land: 40 acres; leveled, checked, ditched; supplied with water by the Turlock Irrigation District

Buildings and structures:

- Farm dwelling, septic tank, and garage. These items, though necessary, are not deemed a part of the farm business.
- Barn for housing work animals, storing hay, and protecting implements and machinery
- Water tank, tower, pump, motor, piping and fittings for lifting and distributing water to house and livestock
- Corral for horses
- 4 canal headgates
- 76 outlet boxes from ditches to checks

Motive power:

- 3 work animals
- Automobile (primarily for personal use, since its operation solely for the farm business would not justify the investment and cost of operation)

Implements and machinery:

- 14-in. sulky plow
- 12-in. walking plow
- 6-ft. spring-tooth harrow
- 10-ft. spike-tooth harrow
- 4-ft. single-disk harrow
- 5-ft. mower
- 10-ft. rake
- 2-row corn and bean planter
- Bean row splitter
- Bean cutter
- 1-row walking cultivator
- Riding cultivator
- Wagon
- Hay stacker
- Fresno scraper
- Hand broadcaster
- Eveners, doubletrees, neck yokes, etc.

Horse equipment:
- 1½ sets of work harness
- 3 horse collars
- 3 halters and tie chains
- Curry comb, brush, barn broom, manure fork, hoof rasp, clippers, etc.

Tools, hand implements, and minor equipment:
- 4 metal tappoons (for use in irrigating)
- Set of carpenter's tools
- Carpenter's vise
- Small set of mechanic's tools
- Pipe vise, stock, dies, and cutter
- Pick, shovels, hoes, pitchforks, crowbar, axe, grindstone, etc.
- Post-hole digger and chain blocks
- Sickle sharpener, rubber boots, wheelbarrow, ladders, baled-hay hooks, oil cans

The list of tools and hand implements comprises the simpler items which are to be found on most well-equipped farms. Their inclusion presupposes ability on the part of the operator to do the simpler tasks of carpentering, pipe fitting, machinery repairing, etc.

Statement of Production.—Table 9 shows the details of production by years, for both the total production of marketable product and the net amounts available for sale after deducting the amounts retained for farm use.

TABLE 9

Production and Amounts of Crops Available for Sale on a 40-Acre Field-Crops Farm

	First year				Second year			Third year	
	Alfalfa, new	Alfalfa, mature	Barley hay	Beans	Alfalfa, mature	Barley hay	Beans	Alfalfa, mature	Grain sorghum
	tons	*tons*	*tons*	*pounds*	*tons*	*tons*	*pounds*	*tons*	*pounds*
Yields per acre	2	5	2	810	5	2	810	5	1,800
Total production	25	62 5	25	10,125	125	25	10,125	125	22,500
Farm use	0	0	25*	200†	0	25*	200†	4	38†
Available for sale	25	62.5	0	9,925	125	0	9,925	121	22,462

* 18 tons fed, balance reserved for future use, since no barley hay is raised in third year.
† Amount reserved for seed.

Financial Statements.—Table 10 has been prepared to show both the production and maintenance requirements in terms of physical quantities and monetary values, and the financial outcome of this farm under the stated conditions of selling prices of farm products and costs of farm operations. Gross income, expenses, and net income have been calculated for each of the 3 years typical of the rotation and for the average of the 3-year period.

The financial showing under the conditions stated is certainly not encouraging. With an average annual net income for the 3-year period

TABLE 10

INCOME AND EXPENSES OF THE 40-ACRE FIELD-CROPS FARM

Annual gross income

	First year	Second year	Third year
Alfalfa hay* at $12.00 a ton	$1,050.00	$1,500.00	$1,452.00
Beans at $0.04 a pound—9,925 pounds	397.00	397.00	.....
Grain sorghum at $1.60 per 100 pounds—22,462 pounds	.....	.....	359.39
Total	$1,447.00	$1,897.00	$1,811.39

Annual expenses

	First year	Second year	Third year
Hired labor† at $2.25 a day of 9 hours	$ 78.75	$ 77.63	$ 50.63
Materials and supplies:			
Alfalfa seed, 250 pounds at $0.20 a pound	50.00	.....	.....
Barley seed, 875 pounds at $1.25 per 100 pounds	10.94	10.94	.....
Sacks‡ at $0.09	10.17	10.17	13.95
Bag twine¶ at $0.75 a pound	0.75	0.75	1.13
Contract work:			
Baling hay* at $2.50 a ton	218.75	312.50	302.50
Threshing beans at $0.45 a sack	50.85	50.85	.....
Threshing grain sorghum at 12½ cents a sack	.....	.....	19.38
Hauling hay* to shipping point at $1.25 a ton	109.38	156.25	151.25
Hauling beans to warehouse at $1.00 a ton	5.07	5.07	.....
Cleaning and fumigating beans at $3.50 a ton	17.75	17.75	.....
Hauling sorghum to shipping point at $1.00 a ton	.....	.....	11.30
Renting extra horses at $1.00 a day	3.00	.....	.....
Irrigation water at $3.82 an acre	152.80	152.80	152.80
Electricity, annual pro rata charge	1.60	1.60	1.60
Repairs and upkeep of equipment:			
Buildings 5.0 per cent of $1,086.00 (Dwelling, garage, and septic tank not included)	54.30	54.30	54.30
Irrigation structures, 2.4 per cent of $370.00	8.88	8.88	8.88
Implements and machinery, 3.6 per cent of $956.00	34.42	34.42	34.42
Harness, halters, collars, and tie chains, 1.0 per cent of $94.00	0.94	0.94	0.94
Small tools, barn, and minor equipment, 1.2 per cent of $180.00	2.16	2.16	2.16
Domestic pumping plant, 0.5 per cent of $548.00	2.74	2.74	2.74
Veterinary expense	10.00	10.00	10.00
Taxes:			
Land in alfalfa	80.75	80.75	80.75
Land in annual crops, farmstead, lanes, and ditches	51.30	51.30	51.30
Buildings (based on average value)	6.08	6.08	6.08
Work animals (based on average value)	4.56	4.56	4.56
Implements and machinery (based on average value)	7.26	7.26	7.26
Hay	0.38	0.65	0.11

* First year, 87.5 tons; second year, 125.0 tons; third year, 121.0 tons.

† First year, 35 days; second year, 34.5 days; third year, 22.5 days.

‡ First year, 113 sacks; second year, 113 sacks; third year, 155 sacks.

¶ First year, 1.0 pound; second year, 1.0 pound; third year, 1.5 pounds.

TABLE 10—(*Concluded*)

Annual expenses—(*Concluded*)

	First year	Second year	Third year
Depreciation of equipment:			
Buildings, 5.0 per cent of $1,086.00 (Dwelling, garage, and septic tank not included)	$ 54.30	$ 54.30	$ 54.30
Irrigation structures, 11.8 per cent of $370.00	43.66	43.66	43.66
Workstock, 10.0 per cent of $375.00	37.50	37.50	37.50
Implements and machinery, 11.4 per cent of $956.00	108.98	108.98	108.98
Harness, collars, halters, and tie chains, 16.6 per cent of $94.00	15.60	15.60	15.60
Small tools, barn, and minor equipment, 12.2 per cent of $180.00	21.96	21.96	21.96
Domestic pumping plant, 7.4 per cent of $548.00	40.55	40.55	40.55
Insurance:			
Horse barn, 1.3 per cent of $225.00	2.92	2.92	2.92
Hay in barn, insured for 6 months, annual premium 2.5 per cent of cash value‖	2.97	3.80	2.14
Employers' liability, 2.9 per cent of payroll	2.28	2.25	1.47
Total	$1,304.30	$1,391.87	$1,297.12

Net farm income

	First year	Second year	Third year	Average for 3 years
Gross income	$1,447.00	$1,897.00	$1,811.39	$1,718.46
Expenses	1,304.30	1,391.87	1,297.12	1,331.10
Net farm income	$ 142.70	$ 505.13	$ 514.27	$ 387.36

‖ On value of $9.50 a ton, first year, 25 tons; second year 32 tons; third year, 18 tons.

of only $387.36, the operator may be tempted to use that portion of his expenses set aside as reserve for repairs and depreciation to increase the amount of money available for personal use, including living expenses, payment of interest on borrowed money, etc. This would add to the income a total of $425.99 (made up of repairs, $103.44; and depreciation, $322.55). But this means dipping into capital and has nothing to recommend it to the man who plans to continue in farming. Taxes, which for this farm average $150.33, might drop, but this is hardly to be counted upon. So, too, the cost of certain contract operations, such as baling or threshing, might decrease. But even with substantial reductions in these items, the net income would still be considered unsatisfactory for most farm operators. Basically four things appear out of line, namely, the selling prices of farm products, the yields now being obtained, the size of the farm, and the type of enterprises which comprise this farm business. The effect on net income of changes in these factors will next be considered.

EFFECTS OF CHANGES IN BASIC DATA

Effect of Changes in Selling Prices.—If selling prices should increase without a corresponding advance in the items of costs, the showing would be more favorable. An increase in the prices of alfalfa hay to $18.00 a ton, of beans to $0.06 a pound, and of grain sorghum to $1.90 per 100 pounds would increase the farm earnings as shown in table 11.

TABLE 11

EFFECT OF INCREASE IN PRICES ON NET FARM INCOME

Order of rotation	Net farm income		
	With original prices	With increased prices	Increase in net farm income
First year	$ 142.70	$ 866.20	$ 723.50
Second year	505.13	1,453.63	948.50
Third year	514.27	1,307.66	793.39
Average	$ 387.36	$1,209.16	$ 821.80

But even these increased prices do not bring the net farm income up to a figure deemed by local operators to be the minimum which a farm of this kind should produce, that is, $1,800 a year. To earn this required minimum through price changes alone is not to be expected in view of the present outlook.

On the other hand should a decrease take place in prices obtainable for hay, beans, and grain sorghum, the amount of net income would be reduced correspondingly. A decrease of 22.7 per cent from $12.00 hay, $0.04 beans, and $1.60 grain sorghum would wipe out all net income. This corresponds to prices of $9.28 for hay, $0.03 for beans, and $1.24 for grain sorghum. Prices still lower than these would mean that the farm could not pay expenses.

Effect of Increased Yields.—An increase in the amount of yield obtainable per acre would provide for a substantial increase in net income. Better yields may often be produced at little or no additional expense in planting and caring for the crop up to harvest, simply by adopting better or more timely cropping practices, attention to detail of operation, and like measures. Increasing the yields of crops from usual to good yields (table 12), through some such means as indicated above, appears entirely feasible. These increased yields, with prices and costs remaining the same as given in table 10, provide net incomes for each of the 3 years of the rotation as shown in table 13.

The effect of increase of yields upon net farm income may be readily noted by comparing the earning power of the farm when only usual

TABLE 12

INCREASED YIELDS RESULTING FROM IMPROVEMENT IN FARMING PRACTICES ON A 40-ACRE FIELD-CROPS FARM

	Alfalfa, new	Alfalfa, mature	Barley hay	Beans	Grain sorghum
	tons	*tons*	*tons*	*pounds*	*pounds*
Present yields per acre	2.0	5.0	2.0	810	1,800
Increased yields per acre	3.5	8.0	3.0	1,080	2,500

TABLE 13

FINANCIAL STATEMENT FOR A 40-ACRE FIELD-CROPS FARM BASED ON INCREASED YIELDS

	First year	Second year	Third year	Average of 3 years
Gross income (prices same as those used in the preceding calculations)	$2,413.00	$2,944.00	$2,851.39	$2,736.13
Expenses (adjusted on the basis of increased production)	1,636.72	1,739.65	1,632.12	1,669.50
Net farm income	$ 776.28	$1,204.35	$1,219.27	$1,066.63

yields were obtained (table 10) with its earning power if good yields were obtained (table 13), prices, farming practices, and basic cost rates remaining the same.

Effect of Change in Size of Farm.—If the size of the farm be increased to 80 acres, the annual and average gross income, expenses, and net farm income will be as shown in table 14, selling prices and the basic costs remaining as given in table 10.

TABLE 14

FINANCIAL STATEMENT FOR AN 80-ACRE FIELD-CROPS FARM

	First year	Second year	Third year	Average of 3 years
Gross income	$3,154.00	$3,810.00	$3,718.80	$3,560.93
Expenses	2,460.88	2,563.92	2,316.34	2,447.05
Net farm income	$ 693.12	$1,246.08	$1,402.46	$1,113.88

Thus by increasing the size of farm from 40 to 80 acres the average annual net income is increased from $387.36 (table 10) to $1,113.88 (table 14), a gain of $726.52. This increase in net income results from a higher degree of efficiency in the use of equipment and in the use of the operator's time. Costs, therefore, do not increase in proportion to the increased gross income obtained from farming the larger area.

CHANGES IN ENTERPRISES

The possibility of increasing the earnings of this farm by changing the plan of organization is worth considering. The calendar of operations shows that the operator, on a 9-hour-day basis, has considerable available time that could be used for other productive purposes. He might work away from the farm if work is obtainable and thus increase his earnings by whatever amount of pay he secures elsewhere. There is also the chance of adding a new enterprise or two. Instead of selling his hay he has the alternative of going into the livestock business. This might consist of feeding cattle or sheep, or installing a small dairy. He might add a flock of hens.

The financial possibilities of any proposed alternative plan or added enterprise can be tested by the procedure set forth in detail in testing the original plan of this farm. Suppose the operator decides to see what would happen if he added a 10-cow dairy, or 500 fowls, or both. If the number decided upon for testing is different from these figures the testing procedure would follow the same general plan although the results would, of course, be different. Tests of these proposals must take into account the added investment required as well as the changes in income and expenses. Analyses of these proposals are given in some detail below.

Addition of a 10-Cow Dairy.—To test the merit of adding a 10-cow dairy herd to a given farm business, with the idea of increasing the net farm income, due consideration must be paid to the following items.

Production per Cow: The amount of product obtained annually per cow has an important bearing upon the net income obtainable per cow. Many of the items of costs are the same irrespective of the amount of milk obtained. There is no justification for trying to make money from poor-producing cows. The average annual production per cow of 3,313 cows tested by associations operating in the Turlock area for the year ending September 30, 1930, was found to be 312.6 pounds of milk fat. Certainly no smaller yield than 312.0 pounds should be deemed satisfactory when adding a few head such as is proposed here.

Sale of newborn calves would add a sum equivalent to possibly eight calves at whatever price is obtainable for them.

Prices Received for Milk: The principal market outlet for dairy products in the Turlock area is through the sale of whole milk for manufacturing purposes. These purchases are paid for on a basis of the milk-fat content of the milk. Prices for the past 5 years have averaged about as shown in table 49 of the Appendix. These data indicate the recent price history, which, coupled with an analysis of the current outlook, will

assist the investigator in deciding upon what selling price he wants to use in testing the financial feasibility of the proposed change of plan.

Initial Investment: Determination of the amount of capital which must be provided to purchase cows, erect a milking barn and milk house, procure equipment, and to meet other initial expenses as well as the influence that such outlays will have upon the annual expenditures, is of considerable importance.

In order to provide a general idea of the amount of capital required for the purchase of cows and equipment and also to show the amount of money which should be set aside each year to take care of the upkeep and maintenance of the invested capital, table 15 has been compiled in some detail.

TABLE 15

INVESTMENT AND ANNUAL OVERHEAD CHARGES REQUIRED FOR A 10-COW DAIRY UNIT

Item	First cost	Annual repairs	Charge for depreciation	
			Rate	Amount
	dollars	*dollars*	*per cent*	*dollars*
Milking barn for 10 head	200.00	10.00	5.0	10.00
Milk house	70.00	5.00	5.0	3.50
Water piping and trough	56.00	2.50	5.0	2.80
Corral for cows	40.00	2.00	5.0	2.00
Dairying equipment*	77.75	0.25	25.5	19.83
Equipment total	443.75	19.75	.....	38.13
Cows	750.00	.....	20.0	150.00
Bull	100.00	.....	16.0	16.00
Herd total	850.00	.....	.....	166.00
Grand total	1,293.75	19.75	.....	204.13

* Same as listed for dairy farm on page 105 with 1 bucket, 6 cans, and milk truck eliminated, because of fewer cows.

Labor Requirements: The care of a 10-cow herd, including the feeding, breeding, milking, care of the milk, and the incidental jobs required in the operation of a dairy unit require 1,480.0 man hours a year or approximately 4 hours a day. This work is fairly evenly distributed throughout the year and does not vary greatly from an average of 123.5 man hours a month. Horse labor to the extent of 18.0 horse days a year, is required at more or less regular intervals.

Operating and Maintenance Charges: Unit factors of expense incurred in the operation of a 10-cow dairy unit are as follows:

ITEM	AMOUNT OR COST PER YEAR
Feed (for 10 cows and 1 bull)	Hay or pasture equivalent to 6 tons per head per year or a total of 66 tons. Concentrates for cows amounting to 1,200 pounds per cow, or 6 tons annually.

ITEM	AMOUNT OR COST PER YEAR
Supplies	Salt: 200 pounds annually. Washing powder: 25 pounds annually. Medicines: $2.50 annually.
Hauling milk	At rate of 3½ cents a pound of milk-fat content of whole milk.
Electricity, annual pro rata charge	$4.50 annually.
Upkeep of dairy equipment	$19.75 (from table 15).
Taxes on cows and bull	Tax rate $3.80 per $100.00: cows assessed at $40.00 each, bull at $50.00, $17.10.
Taxes on hay for herd	Tax rate $3.80 per $100.00: 10 tons assessed at $2.00 a ton, $0.76.
Veterinary expense	$10.00 annually.
Depreciation of equipment	$38.13 (from table 15).
Depreciation of cows and bull	$166.00 (from table 15).
Insurance on cow barn	1.3 per cent of average value: $1.30.
Insurance on hay (stacked)	2.5 per cent on 66 tons for 6 months valued at $9.50 per ton: $15.68.*
Employers' liability insurance	2.9 per cent of payroll.

Effect of Adding 10 Cows to the 40-Acre Field-Crops Farm: A test by the calendar of operations shows that adding 10 cows to the 40-acre field-crops farm (original plan) results in total man and horse labor needs, provides work for the operator, and requires hired labor to the extent shown in table 16.

TABLE 16

MAN AND HORSE LABOR REQUIREMENTS ON A 40-ACRE FIELD-CROPS FARM WITH 10 COWS ADDED

Order of rotation*	Man labor					Horse labor		
	Total required	By operator	Operator's efficiency†	Hired labor	Hired	By farm-owned horses	Efficiency‡	Hired
	9-hour day	*10-hour day*	*per cent*	*9-hour day*	*per cent*	*days*	*per cent*	*days*
First year	351.0	261.5	89 2	60.5	17.2	271.5	36 9	3.0
Second year	324.0	239.0	81.5	58.5	18.1	219.0	29.8	0.0
Third year	295.0	239.5	79 8	29.0	9.8	202.0	27.5	0.0

* Acreage of crops in rotation found in table 3.

† Based on 4 hours a day for 365 days (care of dairy cows) and 6 hours a day for 245 days (available for field work). A total of 293 days of 10 hours each a year.

‡ 245 days available. Horse efficiency based on 735 days, total for three horses.

Table 17 has been prepared to show the effect on net income of adding a 10-cow dairy to this 40-acre field-crops farm. The addition would require the use of 66 tons of hay, formerly sold at a price of $12.00 a ton, but in place of the hay the farm would have for sale 3,120 pounds of milk fat (sold in whole milk) at $0.40 a pound, and 8 calves at $2.00 each. In this statement the expenditures have been reduced by savings in costs of baling and hauling the hay reserved for feed. They have been increased by the additional labor needed to carry on the reorganized plan

of work, by the purchase of concentrates (at $26.00 a ton), salt (at $0.80 per 100 pounds), washing powder (at $0.15 a pound), and by the other items of cost listed under "Operating and Maintenance Charges" pages 41 and 42.

Table 17 records the gross incomes, expenditures, and net incomes for both the original plan and the reorganized plan which includes the 10-cow dairy.

TABLE 17

INCOME AND EXPENSES OF A 40-ACRE FIELD-CROPS FARM WITH AND WITHOUT A 10-COW DAIRY

	First year		Second year		Third year	
	Original plan	With 10-cow dairy	Original plan	With 10-cow dairy	Original plan	With 10-cow dairy
Annual gross income						
Alfalfa hay	$1,050.00	$ 258.00	$1,500.00	$ 708.00	$1,452.00	$ 660.00
Beans	397.00	397.00	397.00	397.00	.....	.....
Grain sorghum	.....	.....	.....	.....	359.39	359.39
Milk fat	.....	1,248.00	.....	1,248.00	.....	1,248.00
Calves	.....	16.00	.....	16.00	.....	16.00
Total gross income	$1,447.00	$1,919.00	$1,897.00	$2,369.00	$1,811.39	$2,283.39
Annual expenses						
Hired labor	$ 72.00	$ 132.75	$ 77.63	$ 129.38	$ 50.63	$ 67.50
Materials	71.86	79.71	21.86	29.71	15.08	22.93
Purchased feeds	.....	156.00	.....	156.00	.....	156.00
Contract work	404.50	266.18	542.12	403.80	484.36	346.06
Irrigation water	152.80	152.80	152.80	152.80	152.80	152.80
Electricity	1.60	6.10	1.60	6.10	1.60	6.10
Veterinary expense	10.00	10.00	10.00	10.00	10.00	10.00
Insurance	7.98	26.72	8.97	27.45	6.53	24.00
Repairs, etc	103.44	123.19	103.44	123.19	103.44	123.19
Depreciation	322.55	526.68	322.55	526.68	322.55	526.68
Taxes	148.33	166.19	150.60	168.46	150.06	167.92
Total expenses	$1,295.06	$1,646.32	$1,391.57	$1,733.57	$1,297.05	$1,603.18
Net farm income						
Net farm income	$ 151.94	$ 272.68	$ 505.43	$ 635.43	$ 514.34	$ 680.21

With the prices and costs as used in this analysis, the various calculations show that with the addition of the 10-cow dairy the average annual net income provided by this farm amounts to $529.44, an increase of only $142.08 over that provided by the original plan (table 10). Interest on the investment required to provide the cows and their equipment is not included as an item of expense in these calculations. If the money for financing this change were borrowed at an interest rate of 7 per

cent, the additional expense chargeable to the dairy unit would have amounted to $90.56 (7 per cent of $1,293.75). It is obvious that the increase in net income is not sufficient to meet this additional demand and to repay the principal of the loan within a reasonable length of time.

It may therefore be concluded that as long as the cost of the other factors of production are as given, the production and sale of hay at $12.00 a ton is almost equally as profitable as feeding that same hay to dairy cows to produce milk fat which sells for $0.40 a pound. However, should hay drop materially in price to $7.00 a ton, other factors of cost remain the same, and milk fat continue to sell at $0.40 a pound, the net income would favor the dairy by $472.07 as shown in table 18.

TABLE 18

AVERAGE ANNUAL FINANCIAL STATEMENT OF A 40-ACRE FIELD-CROPS FARM WITH AND WITHOUT A 10-COW DAIRY

(When market price of alfalfa hay is $7.00 a ton)

	Original plan	With 10-cow dairy	Difference
Average annual:			
Gross income	$1,162.63	$1,964.63	$802.00
Expenses	1,331.10	1,661.03	445.88
Net income	−168.47	303.60	472.07

* All other prices and costs the same as those given in table 17.

Under these conditions, the increased income, after allowing 7 per cent interest on the added investment, returns to the operator only $212.50 ($303.06 — $90.56), which is far from a sufficient amount to provide a satisfactory standard of living.

Addition of 500-Fowl Poultry Flock.—Attention is next directed to testing the possibilities of increasing the net income of this 40-acre field-crops farm by adding a flock of 500 fowls. The effect of this move is described below; some of the general factors that govern the adding of a poultry flock to any farm, and the testing of the addition of such a flock to this farm are considered.

The question of whether or not there is justification for adding a flock of 500 fowls primarily for egg production to any given business requires careful consideration of the following factors.

Production per Flock: If the annual egg production amounts to 150 eggs per hen, then the total production will amount to about 6,250 dozen, which should grade 70 per cent large, 20 per cent mediums, and 10 per cent small. There would, therefore, be available for sale 4,375 dozen large, 1,250 dozen medium, and 625 dozen small eggs.

Prices Received for Eggs: The trend of selling prices of eggs for the past 5 years is given in table 49 of the Appendix.

Mortality of Fowls: Mortality of fowls constitutes a factor which has a marked influence upon the earning capacity of a flock. Death losses ranging from 10 to 30 per cent or more a year are commonly experienced by many operators. A high death rate materially reduces or completely eliminates all chances for profits; a low rate greatly increases the possibilities for success of the poultry enterprise.

In calculating the income possibilities from poultry in the Turlock area, allowance has been made for a rate of mortality of 16 per cent in the items of expense. While this figure may fairly represent an average rate for the better flocks of the area, attention is called to the wide variation in rate of mortality encountered by various producers in the industry.

Depreciation of Fowls: In addition to mortality, every flock suffers from a reduction in productive capacity of the fowls due to aging and disease. As a result most poultrymen plan to replenish their laying flocks with young pullets each year. The replacement percentage varies, but for the purpose of this study, 50 per cent seems reasonable. The culled fowls have a sales value for meat, which has averaged approximately 50 cents a bird during the past few years.

Replacement of Fowls: The plan of operation of the poultry unit used in this text provides for the purchase of pullets, 4 to 6 months of age, with which to start the enterprise and for replacement purposes thereafter to the extent that may be required by flock conditions. Starting with pullets of laying age no replacement would be necessary for the first 2 years other than to offset the losses from mortality and the culling of poor layers from the flock. If 16 per cent is allowed for mortality and 50 per cent for culling, 66 per cent of the flock must be replaced each year. This requires the purchasing of 330 pullets yearly. In this example, these pullets have been purchased at a price which would normally cover all costs of placing them with the flocks, whether obtained at the age of 2 or 3 months and raised, or purchased when about ready to lay. An experienced poultryman can usually brood and rear his pullets for less than the prices charged for good pullets and by so doing would increase his income by whatever net sum he could save.

Initial Investment: To properly care for a flock of 500 fowls, approximately 1 acre of land tightly fenced with an 8-foot fence of 2-inch mesh netting attached to substantial posts properly braced, will be required. A laying house preferably of the shed-roof, open-front type, 18 by 60 feet with additional space 10 by 18 feet for feedhouse and workroom

needs to be constructed and equipped with roosts, dropping boards, nests, feed hoppers, and drinking fountains with the necessary piping and faucets. The costs of these items (exclusive of land) together with the costs of the poultry equipment required for a 500-fowl flock are given in table 19.

TABLE 19

INVESTMENT REQUIRED FOR ESTABLISHING A 500-FOWL POULTRY UNIT

Item	Amount
Poultry house, 18x70 feet	$ 672.00
(If built by the operator himself this cost can be reduced by about $150.00)	
Poultry-yard fencing	114.00
Poultry-house equipment:	
Drinking fountains, including faucets and piping	25.00
Feed hoppers, 8 at $3.00	24.00
Poultry equipment:	
Egg scales	1.25
Egg cases, four 30 dozen cases at $0.50	2.00
Catching net	0.75
Scraper	1.00
Broom	1.50
Scoop shovels, 2	3.00
Hand sprayer	17.50
Wheelbarrow	8.50
Feed buckets, 6	3.00
Egg buckets, 2	0.70
Pullets, 6 months old, 500 at $1.25	625.00
Total	$1,499.20

Labor Requirements: Labor required to care for a 500-fowl flock amounts to the equivalent of 96 man days of 9 hours or approximately 8 man days a month. It is recognized that some variation is bound to occur from month to month but the amount will not be sufficient to materially affect the calendar of operations. In figuring the additional expenses incurred as a result of adding a 500-fowl flock to an existing farm organization, expenditures for labor will be determined by the amount of additional hired labor required to operate the farm under the original plan and after the poultry unit has been added.

To assist in cleaning houses, hauling feeds and litter, and plowing up the yards, one or two horses are needed for an annual total of 6 horse days. The amount of surplus horse labor available on most farms makes this small additional amount of horse work a negligible item.

Operating and Maintenance Charges: Unit factors of expense incurred in the operation of a 500-fowl unit are as follows:

ITEM	AMOUNT OR COST PER YEAR
Feeds and supplies:	
Mash (at 30 pounds per hen per year) 15,000 pounds	At market price
Scratch grains (at 45 pounds per hen per year) 22,500 pounds	At market price
Supplies (grit, oyster shells, disinfectants, seed for green crops, etc.)	At market price
Electricity for pumping water	$ 1.00
Hauling eggs, 209 cases at $0.10	20.90
Taxes	
Buildings, $3.80 per $100.00 on average value of $336.00	12.77
Fowls	6.25
Insurance, Employers' Liability at 2.9 per cent of pay roll	.....
Repairs and upkeep of equipment	
Buildings, 5 per cent of $672.00	33.60
Fencing, 3 per cent of $114.00	3.42
Poultry equipment, 2 per cent of $39.20	0.78
Depreciation	
Buildings, 5 per cent of $672.00	33.60
Fencing, 5 per cent of $114.00	5.70
Poultry house equipment, 20 per cent of $49.00	9.80
Poultry equipment, 30 per cent of $39.20	11.76
Replacement of fowls, 330 pullets at $1.00	$330.00

Effect of Adding a 500-Fowl Unit: Adding a 500-fowl flock to this 40-acre field-crops farm would increase the products for sale annually by 6,250 dozen eggs and 250 culled fowls, once the flock is fully established. Sale of the eggs at a weighted average price of 26 cents a dozen and of the 250 culled fowls at 50 cents each would increase the annual gross income of this farm by $1,750.00.

Expenses would be increased by the additional man labor required amounting to 16 man days the first year, 14½ man days the second year, and 10½ man days the third year. At $2.25 a day, the additional annual expense for labor amounts to $36.00, $31.63, and $23.63 and at 2.9 per cent of the payroll the additional employers' liability insurance amounts to $1.04, $0.95, and $0.69 for each of the 3 respective years. Other expenditures incurred in the operation of the poultry plant are as follows:

ITEM	ANNUAL EXPENDITURE
15,000 pounds of mash at $1.90 per 100 pounds	$285.00
22,500 pounds of scratch grains at $1.50 per 100 pounds	337.50
Supplies (grit, shell, etc.)	28.65
Hauling eggs, 209 cases at $0.10	20.90
Electricity, repairing and maintaining equipment, taxes, and replacement of fowls (as shown under preceding section, "Operating and Maintenance Charges)	$448.68

With these changes in income and expenditures the next step consisted in making up a financial statement for this farm. The findings are set forth in table 20.

TABLE 20

COMPARISON OF FINANCIAL STATEMENT FOR 40-ACRE FIELD-CROPS FARM WITH AND WITHOUT 500-FOWL POULTRY PLANT

	Original plan				With addition of 500 fowls				Difference
	First year	Second year	Third year	Average	First year	Second year	Third year	Average	
Gross income	$1,447.00	$1,897.00	$1,811.39	$1,718.46	$3,197.00	$3,647.00	$3,561.39	$3,468.46	$1,750.00
Exp's..	1,304.30	1,391.87	1,297.12	1,331.10	2,462.07	2,546.18	2,442.17	2,483.47	1,152.37
Net income	$ 142.70	$ 505.13	$ 514.27	$ 387.36	$ 734.93	$1,100.82	$1,119.22	$ 984.99	$ 597.63

The net flock income, as given in table 20, makes no allowance for the labor of the operator nor interest on the investment. If money must be borrowed to finance the adding of a 500-fowl flock at a rate of 7 per cent, and if the operator's labor is considered worth 30 cents an hour, then the net flock income must provide the sum of $104.94 to pay interest and

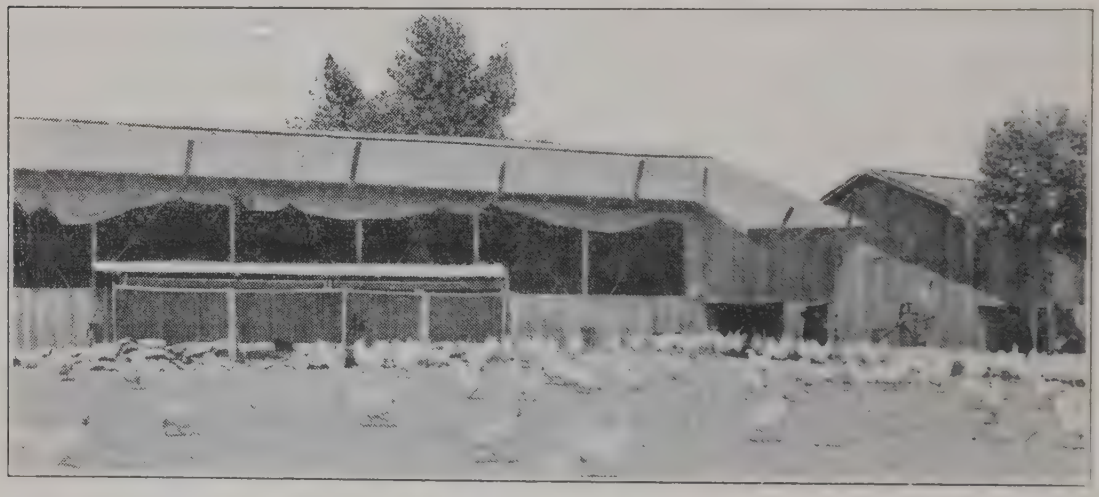


Fig. 7.—White Leghorn hens are maintained for egg production on many farms in the Turlock area. Expansion of the industry appears justified. Studies of net returns indicate that the addition of flocks of 500 hens or more offers an opportunity for many farmers to increase materially the net income of their farms.

$222.29 to compensate the operator. Under the conditions given above the net flock income is sufficient to meet these demands and also provides a sum of $270.40 to use in repaying the principal of the initial loan. The addition of a poultry unit, under conditions as indicated, appears to hold possibilities of adding to the net farm income.

Comments on Adding Livestock Enterprises.—A few comments, applicable alike to poultry and dairy cows, should be stressed.

The first is the year-round program that is a vital part of dairying or poultry keeping. Fowls and cows must be cared for regularly. Feeding, egg collecting, and milking are regularly recurring chores that comprise a routine schedule that must be adhered to at all times. The work, therefore, tends to be confining.

In order to secure maximum returns from either of these enterprises the operator must possess and utilize the knowledge and ability required in the successful handling of livestock. These enterprises call for an intelligent and competent understanding of the requirements of poultry keeping or dairying and an ability and willingness to meet these problems as they arise.

If much or all of the labor must be employed then the returns are proportionately reduced. Whether or not the operator is qualified to do this work himself is a matter for careful determination. Next an inquiry must be instituted into how much time the operator has at his disposal for these added enterprises. This may be determined by the calendar of operations of the present type of business. By adding the time required for either or both of these additional enterprises, an idea will be gained of the operator's ability to contribute the necessary labor, and an indication obtained as to the feasibility of adding a livestock enterprise, such as these, to the farm organization.

ANALYSIS AND FINDINGS OF A 40-ACRE FRUIT FARM

On the 40-acre fruit farm selected for testing, 38 acres are occupied by a mature orchard and vineyard which is divided as follows: 8 acres of canning apricots, 10 acres of black juice grapes, and 20 acres of peaches of canning varieties. The balance of the acreage is utilized by farmstead, lanes, and ditches.

Farming Practices.—The farming practices used in testing this form of organization are based on those customarily followed by orchardists and vineyardists in the Turlock area. A tractor of 10-drawbar horsepower has been used as the motive power for this farm. The farming practices and types of equipment used are shown in detail in the calendar of operations, table 21.

Yields.—The average yields of marketable product used in calculating the labor requirements and net income of this farm are apricots, 4 tons per acre; juice grapes, 6 tons per acre; and peaches, 8 tons per acre.

TABLE 21

CALENDAR OF OPERATIONS FOR A 40-ACRE FRUIT FARM

(Apricots, 8 acres; black juice grapes, 10 acres; peaches, 20 acres)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Tractor*	Implements		Tractor days	Man days			
November	Peaches:	3		Pruning shears	75 trees	0.0	65.0			
	Pruning (three-fourths in Nov.)									
	Apricots:									
	Pruning	2		Pruning Shears	40 trees	0.0	43.0			
	Total					0.0	108.0	17	22.0	86.0
December	Peaches:	3		Pruning shears	75 trees	0.0	21.5			
	Pruning (one-quarter in Dec.)									
	Brush disposal	2	1	Brush burner	9.0 acres	2.5	5.0			
	Spraying	3		1-ton truck, power sprayer	300 trees	0.0	21.0			
	Apricots:									
	Brush disposal	2	1	Brush burner	9.0 acres	0 5	1.0			
	Spraying	3		1-ton truck, power sprayer	300 trees	0.0	9.0			
	Total					3.0	57.5	16	20.0	37.5
January	Juice grapes:									
	Pruning	1		Pruning shears and saw	270 vines	0.0	16.0			
	Total					0.0	16.0	14	16.0	0.0
February	Peaches:									
	Spraying	3		1-ton truck, power sprayer	300 trees	0.0	21.0			
	Apricots:	3								
	Spraying			1-ton truck, power sprayer	300 trees	0.0	9.0			
	Juice grapes:									
	Brush disposal	2	1	Brush burner	18.0 acres	0.5	1.0			
	Tying vines	1			500 vines	0.0	9.0			
	Total					0 5	40 0	11	19 5	20 5

March	Plowing farm ditches	1	1	2-12-in. plow, 5-ft. double disk		0.5	0.5			
	Apricots and peaches:									
	Disking covercrop (2 ways)	1	1	5-ft. double disk	6.0 acres	5.0	5.0			
	Juice grapes:									
	Plowing	1	1	2-12-in. plow	4.8 acres	2.0	2.0			
	Total					7.5	7.5	21	7.5	0.0
April	Apricots and peaches:									
	Ridging for irrigation	1	1	Disk ridger and bucket scraper	48.0 acres	0.5	0.5			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Cultivating	1	1	5-ft. double disk	12.0 acres	2.5	2.5			
	Apricots:									
	Thinning	5			18 trees	0.0	48.0			
	Juice grapes:									
	Disking (2 ways)	1	1	5-ft. double disk	12.0 acres	1.0	1.0			
	Hoeing	1		Hoe	1.0 acre	0.0	10.0			
	Suckering	1			5.0 acres	0.0	2.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.0			
	Total					4.0	68.0	18	20.0	48.0
May	Peaches:									
	Thinning	10			12 trees	0.0	180 0			
	Plowing ditch bottoms	1	1	2-12-in. plow		0.5	0.5			
	Apricots and Peaches:									
	Ridging for irrigation	1	1	Disk ridger and bucket scraper	48.0 acres	0.5	0 5			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Cultivating	1	1	5-ft. double disk	12.0 acres	2.5	2.5			
	Apricots:									
	Hauling props	2		1-ton truck	20.0 acres	0.0	1.0			
	Setting props	1			135 trees	0.0	6.5			
	Juice grapes:									
	Furrowing for irrigation	1	1	Furrower	29.0 acres	0.5	0.5			
	Irrigating	2		Shovels	18.0 acres	0.0	1.0			
	Cultivating (2 ways)	1	1	9-ft. spring-tooth harrow	9.0 acres	1.0	1.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.0			
	Total					5.0	197.5	23	25.0	172.5

(*Continued on p. 52*)

* Tractor of 10 horsepower (drawbar rating) is used for these operations.

TABLE 21—(*Continued*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Tractor*	Implements		Tractor days	Man days			
June	Peaches:									
	Hauling props	2		1-ton truck	20.0 acres	0.0	2.0			
	Setting props	1			135 trees	0.0	16.0			
	Apricots and peaches:									
	Digging borers	1			2.0 acres	0.0	14.0			
	Ridging for irrigation	1	1	Disk-ridger and bucket scraper	48.0 acres	0.5	0.5			
	Irrigating	2		Shovels	18.0 acres	0.0	3.0			
	Cultivating	1	1	5-ft. double disk	12.0 acres	2.5	2.5			
	Apricots:									
	Harvesting (three-quarters or 24 tons in June)									
	Picking (contract)	Crew			1,000 lbs. per man day	0.0	48.0			
	Supervising crew and hauling from orchard (operator)	1		1-ton truck	12 tons	0.0	7.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Juice grapes:									
	Furrowing for irrigation	1	1	Furrower	29.0 acres	0.5	0.5			
	Irrigating	2		Shovels	18.0 acres	0.0	1.0			
	Cultivating	1	1	5-ft. double disk	14.6 acres	1.0	1.0			
		1	1	9-ft. spring-tooth harrow	9.0 acres	1.0	1.0			
	Dusting	1		Knapsack duster	6.0 acres	0.0	1.5			
	Total					5.5	98.0	26	26.0	72.0

July	Peaches:								
	Ridging for irrigation	1	1	Disk ridger and bucket scraper	48.0 acres	0.5	0.5		
	Irrigating	2		Shovels	18.0 acres	0 0	2.0		
	Cultivating	1	1	5-ft. double disk	12.0 acres	2.0	2.0		
	Harvesting (one-third in July, 55 tons)								
	Picking (contract)	Crew			¾ tons	0.0	73.5		
	Supervising crew and hauling from orchard (operator)	1		1-ton truck	12 tons	0.0	7.0		
	Apricots:								
	Harvesting (continued) (one-quarter or 8 tons in July)								
	Picking (contract)	Crew			1,000 lbs.	0.0	16.0		
	Supervising crew and hauling from orchard (operator)	1		1-ton truck	12 tons	0.0	3.0		
	Hauling to shipping point (contract)	.....				.....	.....		
	Juice grapes:								
	Furrowing for irrigation	1	1	Furrower	29.0 acres	0.5	0.5		
	Irrigating	2		Shovels	18.0 acres	0.0	1.0		
	Cultivating	1	1	5-ft. double disk	14.6 acres	1.0	1.0		
	Cultivating	1	1	9-ft. spring-tooth harrow	21.0 acres	0 5	0.5		
	Total					4.5	107.0	26	16.0	91.0
August	Peaches:								
	Harvesting (continued) 105 tons								
	Picking (contract)	Crew			¾ ton	0.0	140.0		
	Supervising crew and hauling from orchard (operator)	1		1-ton truck		0.0	14.0		
	Hauling to shipping point (contract)	.....				.....	.....		
	Juice grapes:								
	Cutting runners	1	1	5-ft. double disk	20.0 acres	0.5	0 5		
	Total					0.5	154.5	26	14.5	140.0

(*Concluded on p. 54*)

* Tractor of 10 horsepower (drawbar rating) is used for these operations.

TABLE 21 (*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Tractor*	Implements		Tractor days	Man days			
September	Apricots and peaches:									
	Hauling and storing props	1		1-ton truck	5.0 acres	0.0	6.0			
	Juice grapes:									
	Harvesting (one-half or 30 tons in September)	.....				.....	.....			
	Picking (contract)	Crew				.....	.....			
	Supervising crew and hauling from vineyard (operator)	1		1-ton truck	10 tons	0.0	3.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					0.0	9.0	25	9.0	0.0
October	Apricots and peaches:									
	Ridging	1	1	Disk ridger and bucket scraper	48 acres	0.5	0.5			
	Irrigating	2		Shovels	18 acres	0.0	3.0			
	Disking	1	1	5-ft. double disk	12 acres	2 5	2.5			
	Seeding covercrop	2		1-ton truck	30 acres	0 0	2.0			
	Harrowing	1	1	12-ft. spike-tooth harrow	29 acres	1.0	1.0			
	Plowing farm ditches	1	1	2-12-in. plow		0.5	0.5			
		1	1	5-ft. double disk						
	Juice grapes:									
	Harvesting (continued) (one-half or 30 tons in Oct.)									
	Picking (contract)	Crew				.....	.....			
	Supervising crew and hauling from vineyard (operator)	1		1-ton truck		0 0	3.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					4.5	12.5	22	10 0	2 5
	Total for year					35.0	875 5	245	205 5	670 0

* Tractor of 10 horsepower (drawbar rating) is used for these operations.

THE CALENDAR OF OPERATIONS

The calendar of operations given in table 21 is typical. It shows what tasks must be performed to take care of the orchards and vineyard, and to harvest and handle the mature crops. Chores and other routine work have not been included. A discussion of this phase is given under the general description of calendar of operations on page 15.

The amount of man labor required to operate a fruit farm such as this, requires a total of 875½ man days annually of which the operator can personally perform only 205½. As there are on the average a total of 278 days a year available for soil and tree work, the operator utilizes 73.9 per cent of his time productively. To assist him in taking care of all tasks he must employ additional help amounting to more than three times the amount that he himself can contribute, or 76.5 per cent of the total man labor requirements. In addition he must hire the picking of grapes and the hauling of his fruits to shipping points. These are shown (table 21), however, as contract work and are not reduced to a day-labor basis.

No provision can be made for the steady employment of men because of the varying nature of the work which necessitates the employment of different classes of workers (e.g., pruners, spraymen, fruit thinners, fruit pickers, irrigators, etc.), and the hiring of several men at a time for short periods when needed. This results in the necessity for hiring and paying for labor on an hourly or daily basis.

One of the interesting features connected with the operation of this farm is the opportunity it provides for a well-rounded program for the operator. It is expected and planned that the operator handles the cultivation; cleans the ditches; operates and services the tractor; helps with the irrigation; digs borers; ties, suckers, and dusts the grapevines; helps with the orchard pruning and brush burning; assists in propping; supervises the harvest; and hauls the fruit from the orchard and vineyard to where it is picked up by the contract hauler. This program, as shown in table 22, provides work throughout the year.

Yet notwithstanding the well-distributed amount of work it is evident from table 22 that with the exception of June, the operator has some spare time available for other productive uses every month in the year. The months in which he has the greatest amount of available time are from July to October, and again in January and March. This condition indicates the desirability of testing alternative propositions.

TABLE 22

UTILIZATION OF OPERATOR'S TIME ON A 40-ACRE FRUIT FARM AND DAYS AVAILABLE FOR ADDITIONAL WORK

Month	Number of man days*	
	Operator employed	Operator free†
November	22.0	4.0
December	20.0	6.0
January	16.0	10.0
February	19.5	4.5
March	7.5	18.5
April	20.0	6.0
May	25.0	1.0
June	26.0	0.0
July	16.0	10.0
August	14.5	11.5
September	9.0	17.0
October	10.0	16.0
Total	205.5	104.5

* 9-hour day.

† Based on a 26-work-day month except February which is a 24-work-day month.

FINANCIAL RESULTS

Pertinent data relating to items of investment, total yield of marketable products, selling prices, and costs of operation and maintenance of the 40-acre fruit farm were compiled for use in testing the financial results of the farm business for a typical year. These data and the analysis of the financial results are presented in the sections which follow.

Investment Items.—Items, representing the total investment required to completely equip this farm as a fully developed and operating unit, are listed in detail below.

Land: 40 acres; leveled and ditched; supplied with water by the Turlock Irrigation District

Buildings and structures:

- Farm dwelling, septic tank, and garage. These items, though necessary, are not deemed a part of the farm business
- Implement shed for housing tractor, truck, implements, orchard and vineyard equipment
- Water tank, tower, pump, motor, piping and fittings for lifting and distributing domestic water supply
- 4 canal headgates
- 76 outlet boxes from ditches to checks

Motive power:

- Tractor, 10-horsepower (drawbar rating)
- Motor truck, 1½-ton capacity

Implements and machinery:
- 2–12-inch moldboard plow.
- 5-ft. double disk harrow
- Spring-tooth harrow, 3–4½-ft. sections
- Spike-tooth harrow, 3–5½-ft. sections
- Reversible disk ridger
- Bucket scraper

Orchard and vineyard equipment:
- Brush burner
- 12 ladders
- 3 pruning shears, long handled
- 3 pruning shears, hand
- 3 pruning saws
- Sulfur duster, hand
- 2 spray-mixing barrels
- 12 picking buckets
- 12,000 tree props and hooks
- Seed broadcaster, hand
- (Lug boxes rented from fruit buyer)

Tools, hand implements, and minor equipment:
- 4 metal tappoons (for use in irrigating)
- Carpenter's tools
- Carpenter's vise
- Set of mechanic's tools
- Mechanic's vise
- Pick, shovels, hoes, crowbar, axe, grindstone, etc.
- Whitewashing brush, rubber boots, gopher traps, etc.
- Oil cans, funnels, gasoline can, etc.

This list of equipment comprises the minimum needed to carry on the farm work. It presupposes ability on the part of the operator to do minor jobs of carpentering, implement repairing, tractor and truck maintenance.

Statement of Production.—The total yield of marketable products annually produced on this farm and upon which the gross income is calculated is given in table 23.

TABLE 23

Production and Amounts of Crops Available for Sale on a 40-Acre Fruit Farm

	Canning peaches	Canning apricots	Juice grapes
	tons	*tons*	*tons*
Yield per acre	8	4	6
Total annual production	160	32	60
Available for sale	160	32	60

Financial Statement.—The unit factors involved in the production and maintenance of this farm and the financial results of a typical year's business, with selected data on yields, selling prices, and costs of operation are set forth in detail in table 24.

The net farm income is $872.12 when selling prices and costs are as given in the financial statement (table 24). If this income is not sufficient to satisfy or to meet obligations of the operator, particularly if a

TABLE 24

INCOME AND EXPENSES OF A 40-ACRE FRUIT FARM

Annual gross income	
Canning peaches, 160 tons at $20.00	$3,200.00
Canning apricots, 32 tons at $30.00	960.00
Juice grapes, 60 tons at $22.50	1,350.00
Total	$5,510.00

Annual expenses	
Hired labor:	
4,765½ hours at $0.25	$1,191.38
1,264½ hours at $0.30 (pruning and spraying)	379.35
Materials and supplies:	
Covercrop seed:	
560 pounds *Melilotus indica* at $0.06	33.60
420 pounds vetch at $0.08	33.60
Gasoline, 630 gallons at $0.15	94.50
Oil, 32 gallons at $0.64	20.48
Grease, 26 pounds at $0.25	6.50
Spray materials:	
Bluestone, 2,120 pounds at $0.08	169.60
Quicklime, 2,208 pounds at $0.01	22.08
Lime-sulfur, 1,000 gallons at $0.18	180.00
Dusting materials, 450 pounds sulfur at $0.04	18.00
Grape containers, 4,800 No. 2 grape lugs at $0.10	480.00
Contract work:	
Picking and field-packing grapes, 60 tons at $3.00	180.00
Rental of lugs, 7,680 at $0.01	76.80
Hauling fruit and lugs, 252 tons at $1.50	378.00
Irrigation water, 40 acres at $5.62	224.80
Electricity, annual pro rata charge	2.80
Repairs and upkeep of equipment:	
Buildings*, 5.0 per cent of $681.00	34.05
Irrigation structures, 2.4 per cent of $370.00	8.88
Tractor, 2.1 per cent of $973.00	20.43
Truck, 2.7 per cent of $600.00	16.20
Implements and machinery, 2.8 per cent of $503.00	14.08
Orchard and vineyard equipment, 0.7 per cent of $2,013.00	14.09
Small tools and minor equipment, 1.4 per cent of $83.00	1.16
Domestic pumping plant, 0.5 per cent of $548.00	2.74
Taxes:	
Land in orchard	170.24
Land in vineyard	76.00
Land in farmstead, lanes, and ditches	6.84
Buildings (based on average value)	4.18
Tractor (based on average value)	5.93
Truck, county (based on average value)	5.32
Truck, state (based on average value)	8.00
Orchard equipment (based on average value)	15.20
Implements, machinery (based on average value)	3.80

* Dwelling, garage, and septic tank not included.

Annual expenses—(*Concluded*)

Depreciation of equipment:	
Buildings*, 5.0 per cent of $681.00	$ 34.05
Irrigation structures, 11.8 per cent of $370.00	43.66
Tractor, 10.0 per cent of $973.00	97.30
Truck, 6.0 per cent of $600.00	36.00
Truck tires, 20.0 per cent of $95.00	19.00
Implements and machinery, 10.0 per cent of $503.00	50.30
Orchard equipment, 17.5 per cent of $2,013.00	352.28
Small tools and minor equipment, 13.2 per cent of $83.00	10.96
Domestic pumping plant, 7.4 per cent of $548.00	40.55
Insurance	
Truck, 1.6 per cent of $600.00	9.60
Employers' liability, 2.9 per cent of $1,570.73	45.55
Total	$4,637.88

Net farm income

Gross income	$5,510.00
Expenses	4,637.88
Net farm income	$ 872.12

* Dwelling, garage, and septic tank not included.

heavy indebtedness requires the payment of substantial sums for interest on borrowed money and repayment of principal, then ways of increasing net income warrant attention. Thinning of fruit, with its accompanying outlay of $487.00, is liable to be lessened or other operations neglected even though contrary to good farming practices. One tendency is to utilize amounts of money which should be set aside for upkeep and replacement of equipment. Such practices are detrimental in the long run and should be resorted to only in cases of extreme urgency. The appropriation of the money reserved for repairs and depreciation would add $795.73 to the operator's cash funds, but this practice is inadvisable because the time will eventually come when lack of funds to maintain working equipment will cause substantial depletion of the farm capital.

EFFECTS OF CHANGES IN BASIC DATA

Effect of Change in Selling Prices.—An increase in the selling price of any one or all of the commodities produced on this farm would favorably affect the net farm income. Assuming prices of $45.00 a ton for apricots, $32.50 a ton for juice grapes, and $35.00 a ton for canning peaches, the gross farm income would be increased to $8,990.00. With costs remaining the same as those given in table 24, the net income from this farm would thereby be increased to $4,352.12.

Conversely, if prices obtainable for the fruit crops of this farm decreased to $15.00 a ton for apricots, $10.00 a ton for peaches, and $20.00 a ton for grapes, the gross farm income would be reduced to $3,280.00, which, with expenses of $4,637.88 (table 24), results in a net loss of $1,357.88.

Effect of Increased Yields.—Attention may well be paid to ways and means of producing better yields. If it is possible to increase the yields from the rates used in testing the original plan of this 40-acre fruit farm to those shown in table 25, the effect upon net farm income, shown in the same table, is sufficiently great to justify all reasonable effort to bring this about.

TABLE 25

EFFECT OF INCREASED YIELDS ON INCOME OF A 40-ACRE FRUIT FARM WITH BASIC SELLING PRICES AND COSTS REMAINING THE SAME

Product	Yields per acre		Original total income	Total income with increased yields	Increase in income over original production
	Original yield	Increased yield			
	tons	*tons*			
Apricots, canning*	4	6	$ 960.00	$1,440.00	$ 480.00
Juice grapes*	6	8	1,350.00	1,800.00	450.00
Peaches, canning*	8	12	3,200.00	4,800.00	1,600.00
Total gross income	.....	.....	5,510.00	8,040.00	2,530.00
Expenses	.....	.....	4,637.88	5,547.13†	909.25
Net farm income	.....	.....	$ 872.12	$2,492.87	$1,620.75

* The acreage for these crops are: apricots, 8 acres; grapes, 10 acres; and peaches, 20 acres.
† Adjusted to cover additional cost of harvesting larger yields.

Yields such as these are by no means unattainable. They are being secured on the better lands and by the more competent orchardists. They are certainly worth the effort if there is a promise of obtaining them without incurring a corresponding increase in expense. On the other hand, the orchardist should be aware that neglect or carelessness will reduce his yields of marketable fruit. Any substantial reduction in the yields produced will materially reduce the earnings of that orchard.

CHANGES IN ENTERPRISES

Analysis of the calendar of operations indicates that the orchardist, whose major activities now center in the handling of a 40-acre orchard, has some available time that he could devote to additional productive labor. This suggests the possibility of farming additional acreage, doing custom work with his tractor, drying fruit instead of selling it fresh, or adding a livestock enterprise.

To increase the acreage farmed, the operator would be confronted with the problem of obtaining control of additional land by purchase or lease. He would further be confronted with the problem of selecting crops or livestock enterprises for the additional acreage obtained which would least interfere with the operation of the present organization. For the operator who can command the necessary finances and who possesses the requisite ability to handle a larger tract of land, this proposal has possibilities.

The utilization of spare time, by contracting with neighboring farmers to do plowing, disking, or other tractor operations, offers an excellent opportunity for the operator to increase his annual income, provided such work is not allowed to interfere with the proper care of his farm.

Effect of Drying Fruit.—Under some conditions and when suitable varieties are produced, the grower has the alternative (and possible necessity) of drying his fruit instead of selling it fresh. This raises a question concerning the financial feasibility of such procedure. The answer lies in calculating and comparing the probable gross incomes, costs, and net incomes obtainable from each of the two practices. For purposes of comparison, assuming that varieties suited for fresh shipment or drying are being produced, a test will be made of the effect on net income of drying the apricots and peaches produced on this 40-acre fruit farm. If the fruit dries on a ratio of 4 to 1 (4 tons of fresh fruit making 1 ton of dried fruit) this farm will have for sale, in place of the 32 tons of fresh apricots and 160 tons of fresh peaches, 8 tons of dried apricots, 2 tons of apricot pits, and 40 tons of dried peaches. The peach pits have no market value.

Certain changes will occur in the basic costs already set forth if drying takes the place of selling fresh. These changes include:

1. Fewer hours are required to pick fruit as less care need be exercised in picking fruit for drying than for canning (or shipping). The rate for picking apricots is 1,200 pounds per man day instead of 1,000 pounds, or a saving for the 8 acres of 94½ hours. The rate of picking peaches for drying is 2,000 pounds per man day instead of 1,500 pounds. This means a saving of 481½ hours in picking the 20 acres of peaches.
2. Cost of cutting is an added expense.
3. Labor for drying requires an expenditure of 336 man hours to dry the apricots and 1,760 hours to dry the peaches.
4. Sulfur must be purchased for use in drying, amounting to 256 pounds for the apricots and 1,260 pounds for the peaches.
5. Seventy-two sacks are needed for the apricot pits.

6. Drying equipment involves an investment of $2,125. The charge for upkeep, depreciation, taxes, and insurance amounts to $211.25 annually, chargeable to the fruit dried.

7. Hauling fruit to shipping point—a contract operation—is reduced from 32 tons to 10 tons in the case of the apricots, and from 160 tons to 40 tons for peaches.

8. Instead of renting lug boxes the farm must invest $150.00 in 600 lug boxes to care for the apricots, or $500.00 for 2,000 lug boxes to care for the peaches, or both the apricots and peaches if the two crops are dried. The annual charge for boxes amounts to $0.08 each when farm owned.



Fig. 8.—The drying of such tree fruits as freestone peaches and apricots, though entailing additional equipment and added expenses, offers opportunities for increasing net farm income and supplies an additional outlet for products of the area.

After allowing for these changes and assigning 25 cents an hour for picking, 12 cents per 50-pound lug for cutting apricots, and 5 cents per 50-pound lug for cutting peaches, 30 cents an hour for dry-yard labor, 4 cents a pound for sulfur, 5 cents each for second-hand sacks, and other costs as already indicated, the results are summarized and given in table 26.

TABLE 26

COST OF DRYING APRICOTS AND PEACHES ON A 40-ACRE FRUIT FARM

	Drying costs for		
	8 acres of apricots*	20 acres of peaches*	Both peaches and apricots
Net added cost	$404.91	$767.27	$960.33
Additional cost of drying per green ton	12.65	4.80	5.00
Additional cost per dried ton	$ 50.60	$ 19.32	$ 20.00

* Production in tons of fresh fruit is 32 tons of apricots and 160 tons of peaches.

The figures given in table 26 show that if apricots or peaches are dried, to produce a net farm income equal to that received from fresh fruits (e.g., $20.00 for peaches and $30.00 for apricots) the dried fruit must sell for four times as much (to allow for loss in weight through drying) plus the cost of drying. Thus, apricots which will bring $30.00 as fresh fruit must command a selling price of $170.60 a ton for the dried product (or 8.5 cents a pound). Likewise a price of $99.20 a ton for dried peaches (5.0 cents a pound) corresponds to $20.00 a ton for fresh fruit. If both can be sold fresh at a weighted price of $21.67 a ton then the corresponding price for dried fruit must be $109.92 a ton (or 5.5 cents a pound) to be equal. There is a direct relation between prices of fresh and dried fruit as these affect the net income. If peaches sold fresh bring $20.00 a ton, and the price of the dried fruit is in excess of 5.1 cents a pound, drying pays. If the price for dried peaches is less than 5.1 cents a pound, drying does not pay. The relation of $30.00 a ton fresh and 8.6 cents a pound dried holds for apricots.

Effect of Adding a 500-Fowl Poultry Enterprise.—The effect on net income of adding a 500-fowl poultry flock to this 40-acre fruit farm can be tested by the procedure presented in detail (pages 44 to 48) for the 40-acre field-crops farm.

The first point to be considered is whether or not the operator has the time available to care for the flock. By comparing time left free from orchard operations with the work required by the flock, it is evident that there will be no undue piling up of work from July to October and during February and March. The operator may be obliged to work more than 9 hours a day or have additional help during the remaining months as follows:

Month	Additional labor required in care of poultry in man days
November	4.0
December	2.0
February	3.5
April	2.0
May	7.0
June	8.0
Total additional days	26.5

Hired labor could be employed for the equivalent of 26½ man days or the operator could perform this additional labor required by working a longer day (e.g., approximately 1½ hours more a day in November and February, 1 hour more in December and April, 2½ hours more in May, and 3 hours more in June) or else work on Sundays. While this can be done, for most orchardists it is not likely to prove attractive. However,

should the need for additional income be paramount, the adding of this poultry enterprise will increase the net farm income by $567.91, less any interest and repayment of borrowed funds required to finance the change. If there are no such deductions, then the net farm income can be raised from $872.12 from fruit alone to $1,440.03 by combining a poultry enterprise with the orchard.

FINANCIAL RESULTS OF A 20-ACRE FRUIT FARM

Since a large number of the fruit farms in the Turlock area consist of 20 acres instead of the 40-acre size used in this test, it will be well to examine the financial showing on these smaller units. Assuming the same kinds of crops, in the same proportional acreage, with selling prices, yields, and costs as given in the basic detailed table, the showing is as follows:

Gross income	$2,755.00
Expenditures	2,490.76
Net farm income	264.24

Several influences tend to result in a small annual net farm income. One is low yields. Another is a relatively low level of selling prices (in comparison with prices of former years). A third is the heavy investment required for implements and machinery. Other than fewer props, the investment is about the same as that needed to equip a 40-acre fruit farm. A relatively higher per-acre charge for depreciation and maintenance of equipment must be met on the 20-acre farm and this automatically affects the net farm income. The charge for use of the tractor is high. It is utilized but 24½ days a year at a total annual cost (not including interest) of $206.80. A question arises whether the keeping of two horses in place of a tractor would be more economical. The cost of keeping two horses amounts to $213.49 annually, which indicates no possible saving by substituting horses for the tractor. Furthermore, the change might require the erection of a small barn and the procuring of harness, collars, halters, etc., at an added investment of about $312.00. If the farm is not equipped, the initial investment for horses would be less. With horses costing $125.00, the total investment would amount to $562.00 against the $973.00 required for the tractor. Equipping with horses instead of a tractor will necessitate a constant round of chores from which the tractor now relieves the operator.

The operator on a 20-acre farm such as this is kept busier than on a 40-acre farm. The calendar of operations for this 20-acre fruit farm shows a total need for 461 man days of which the operator can perform

219 days of labor. On a 278-day year his efficiency is thus 79 per cent, but even so, some time would be available for other productive labor. This is shown in table 27.

TABLE 27

Utilization of Operator's Time on a 20-Acre Fruit Farm and Days Available for Additional Work

Month	Number of man days*	
	Operator employed	Operator free†
November	22.0	4.0
December	20.0	6.0
January	8.0	18.0
February	16.0	8.0
March	10.5	15.5
April	21.0	5.0
May	24.0	2.0
June	26.0	0.0
July	26.0	0.0
August	26.0	0.0
September	14.0	11.0
October	5.0	21.0
Total	219.0	91.0

* 9-hour day.

† Based on a 26-work-day month except February which is a 24-work-day month.

In considering additional work the months of April to August inclusive should be kept in mind. These months reflect a rather full-time schedule and any added enterprises should be of such a nature that they do not make excessive demands during these spring and summer months.

ANALYSIS AND FINDINGS OF A 40-ACRE TRUCK FARM

This farm is primarily used for the production of cantaloupes and Honey Dew melons, with alfalfa and an occasional green-manure crop included in the rotation to improve or maintain the crop-producing power of the land, and some barley hay for feed for work stock. A 9-year rotation is the basis of the cropping plan, consisting of alfalfa, 3 years; barley hay and melons, double-cropped, 1 year; cantaloupes, 4 years, with a green-manure crop added between the second and third crops; melons, 1 year. To distribute the work, maintain a fairly steady income year after year, and provide for a uniform acreage in crops, three fields of 12½ acres each are provided and the balance of the acreage (2½ acres) is utilized by farmstead, ditches, and lanes. The basic plan is given in table 28.

TABLE 28

ROTATION OF CROPS ON A 40-ACRE TRUCK FARM

Year of rotation	Field 1	Field 2	Field 3
1	Alfalfa, new seeding	Barley hay followed by melons	Cantaloupes
2	Alfalfa	Cantaloupes	Cantaloupes
3	Alfalfa	Cantaloupes and a green manure crop	Melons
4	Barley hay followed by melons	Cantaloupes	Alfalfa, new seeding
5	Cantaloupes	Cantaloupes	Alfalfa
6	Cantaloupes and a green manure crop	Melons	Alfalfa
7	Cantaloupes	Alfalfa, new seeding	Barley hay followed by melons
8	Cantaloupes	Alfalfa	Cantaloupes
9	Melons	Alfalfa	Cantaloupes and a green manure crop

The basic rotation is indicated in its logical order in Field 1. The place in the rotation of the other two fields is shown in the last two columns of table 28. As in the case of the field-crops farm, each 3-year period of the rotation is a repetition of the first period, so far as acreage of crops is concerned. The annual crop acreages for each of the 3 typical years of the rotation are given in table 29.

TABLE 29

CROP ACREAGES FOR EACH OF THE 3 TYPICAL YEARS OF THE ROTATION ON A 40-ACRE TRUCK FARM

Crop	Order of rotation		
	First year	Second year	Third year
	acres	*acres*	*acres*
Alfalfa, new seeding	12.5	0.0	0.0
Alfalfa, mature	0.0	12.5	12.5
Barley hay (Double-cropped)	12.5	0.0	0.0
Melons (Double-cropped)		0.0	12.5
Cantaloupes	12.5	25.0	12.5

Farming Practices.—These consist of the usual farm practices customarily followed by growers of these crops in the Turlock area. The details are set forth in the calendars of operations (tables 30, 31, and 32) prepared for this farm.

Yields.—The yields of marketable products used in testing the efficiency of labor and the net income obtainable from this farming plan are as follows:

Alfalfa (new seeding)	2 tons per acre
Alfalfa (mature)	5 tons per acre
Barley hay	2 tons per acre
Cantaloupes	150 standard crates per acre
Melons	6 tons per acre



A



B

Fig. 9.—*A*, Honey Dew melons are being harvested for sale to cash buyers. *B*, Loads of melons arriving by team and by truck at one of the typical melon markets where cash buyers bid on each individual lot. Such markets provide an outlet for the bulk of the melon crop in the Turlock area.

THE CALENDAR OF OPERATIONS

Tables 30, 31, and 32 present a calendar of operations for each of the 3 typical years of the rotation when operations differ. Each shows the operations to be performed, the size of the equipment used, the amount of work done a day, and the total labor requirements—both man and horse. Chores and other routine labor are not included, for the reasons already given on page 15.

TABLE 30

CALENDAR OF OPERATIONS FOR A 40-ACRE TRUCK FARM FOR FIRST YEAR OF ROTATION

(Seeding alfalfa, barley hay and melons, and cantaloupes)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Barley hay:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Harrowing	1	3	6-ft. spring-tooth harrow	4.9 acres	7.5	2.5			
	Seeding	2	2	Wagon and broadcaster	30.0 acres	1.0	1.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	16.2 acres	2.0	1.0			
	Total					34.0	13.0	17	12.5	0.5
December	Alfalfa (new seeding):									
	Disking	1	2	4-ft. single disk	6.5 acres	4.0	2.0			
	Plowing levees	1	2	12-in. plow	13.0 acres	2.0	1.0			
	Checking and leveling	1	4	5-ft. Fresno scraper	5.0 acres	10.0	2.5			
	Dragging	1	2	8-ft. plank drag	6.5 acres	4.0	2.0			
	Setting outlet boxes	2			4.0 acres	0.0	6.0			
	Total					20.0*	13.5	16	10.5	3.0
January	Alfalfa (new seeding):									
	Spreading manure	1	2	Wagon	8 tons	25.0	12.5			
	Total					25.0	12.5	14	12.5	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Alfalfa (new seeding):									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Cantaloupes:									
	Plowing (4 acres)	1	3	14-in. sulky plow	1.9 acres	6.0	2.0			
	Total					29.5	10.5	11	10.5	0.0

March	Alfalfa (new seeding):									
	Disking	1	2	4-ft. single disk	6.5 acres	4.0	2.0			
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.9 acres	9.0	3.0			
	Seeding	2	2	Wagon and broadcaster	30.0 acres	1.0	1.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	13.5 acres	2.0	1.0			
	Cantaloupes:									
	Plowing (8½ acres)	1	3	14-in. sulky plow	1.9 acres	13.5	4.5			
	Disking (twice)	1	2	4-ft. disk	6.5 acres	8.0	4.0			
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.0 acres	9.0	3.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	8.1 acres	3.0	1.5			
	Planting	2	2	Planting sled	8.0 acres	3.0	3.0			
	Total					52.5	23.0	21	21.0	2.0
April	Alfalfa (new seeding):									
	Clipping	1	2	5-ft. mower	8.1 acres	3.0	1.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Barley hay:									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	18.0 acres	0.0	1.5			
	Cantaloupes:									
	Replanting skips and hoeing	1		Hoe	1.0 acre	0.0	12.5			
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Cultivating	1	1	5-ft. spike-tooth harrow	8.0 acres	1.5	1.5			
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Total					15.5	24.5	18	18.0	6.5

(*Continued on p. 70*)

* Includes rental of 1 horse for 3 days for scraper work.

TABLE 30—(*Continued*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Barley hay:									
	Hauling and storing in barn	2	2	Wagon	10 tons	5.0	5.0			
	Melons:									
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Harrowing	1	3	6-ft. spring-tooth harrow	4.9 acres	7.5	2.5			
	Cantaloupes:									
	Thinning and weeding	1		Hoe	1.0 acre	0.0	12.5			
	Cultivating	1	1	Walking cultivator	8.0 acres	1.5	1.5			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Furrowing for irrigation	1	2	12-in. lister	8.0 acres	3.0	1 5			
	Irrigating	2		Shovels	6.0 acres	0.0	4.0			
	Total					37.5	37.5	23	23.0	14.5
June	Alfalfa (new seeding), first cutting (late in month):									
	Mowing	1	2	5-ft. mower	8.0 acres	3 0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	0.5			
	Hauling and stacking	2	2	Wagon	10 tons	1.0	1.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Melons:									
	Harrowing	1	2	10-ft. spike-tooth harrow	8.0 acres	3.0	1.5			
	Planting	2	2	Planting sled	8.0 acres	3.0	3.0			
	Reseeding skips	1		Hoe	5.0 acres	0.0	2.5			
	Cantaloupes:									
	Cultivating	1	1	Walking cultivator	8.0 acres	1.5	1 5			
	Furrowing	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Irrigating (twice)	2		Shovels	6.0 acres	0.0	8 0			
	Dusting	1		Knapsack duster	9.0 acres	0 0	1.5			
	Total					16.5	25 5	26	18.5	7.0

July	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (new seeding), second cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	1.0			
	Hauling and stacking	2	2	Wagon	10 tons	2.0	2.0			
	Melons:									
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Cultivating	1	1	5-ft. spike-tooth harrow	8.0 acres	1.5	1.5			
	Weeding and thinning	1		Hoe	1.0 acre	0.0	12.5			
	Furrowing	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Irrigating	2		Shovels	9.0 acres	0.0	3.0			
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Cantaloupes:									
	Irrigating	2		Shovels	6.0 acres	0.0	4.0			
	Harvesting (4/5 or 1,500 crates):									
	Picking and packing (contract)	.....				.....	.....			
	Hauling from field and supervision	1	2	Wagon	450 crates	7.0	11.5			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					25.5	44.5	26	26.0	18.5
August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (new seeding):									
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Third cutting:									
	Same as second cutting					7.0	5.5			
	Melons:									
	Furrowing for irrigation	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Irrigating	2		Shovels	9.0 acres	0.0	3.0			
	Cultivating	1		1-horse walking cultivator	8.0 acres	1.5	1.5			

(Concluded on p. 72)

TABLE 30—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
August (*concluded*)	Cantaloupes:									
	Harvesting (continued, 375 crates)									
	Picking and packing (contract)	.....				.....	.....			
	Hauling from field and supervision by operator	1	2	Wagon	450 crates	2.0	4.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					14.5	19.5	26	16.0	3.5
September	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (new seeding):									
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Fourth cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	0.5			
	Melons:									
	Harvesting (2/3 or 50 tons in September)									
	Picking	2		Melon-picking bag	12 tons	0.0	8.5			
	Loading	1			18 tons	0.0	3.0			
	Hauling (contract)	.....				.....	.....			
	Total					6.0	17.0	25	12.0	5.0
October	Alfalfa (new seeding):									
	Hauling and stacking	2	2	Wagon	10 tons	1.0	1 0			
	Melons:									
	Harvesting (continued, 21 tons):									
	Picking	2			12 tons	0.0	4.0			
	Loading	1			18 tons	0.0	1.5			
	Hauling (contract)	.....				.....	.....			
	Disking (two ways)	1	2	4-ft. disk	3.2 acres	8.0	4.0			
	Total					9.0	10 5	22	7 5	3 0
	Total for year					285.5*	251.5	245	188.0	63.5

TABLE 31

CALENDAR OF OPERATIONS FOR A 40-ACRE TRUCK FARM FOR SECOND YEAR OF ROTATION

(Mature alfalfa and cantaloupes)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Total					4.0	2.0	17	2.0	0.0
December	Total					0.0	0.0	16	0.0	0.0
January	Alfalfa (mature):									
	Renovating	1	3	6-ft. spring-tooth harrow	4.8 acres	9.0	3.0			
	Cantaloupes:									
	Plowing (9.5 acres)	1	3	14-in. sulky plow	1.9 acres	15.0	5.0			
	Total					24.0	8.0	14	8.0	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Cantaloupes:									
	Plowing (15.5 acres)	1	3	14-in. sulky plow	1.9 acres	24.0	8.5			
	Total					28.0	10.5	11	10.5	0.0
March	Cantaloupes:									
	Disking (twice)	1	2	4-ft. disk	6.5 acres	16.0	8.0			
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	4.0 acres	18.0	6.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	8.0 acres	6.0	3.0			
	Planting	2	2	Sled planter	8.0 acres	6.0	6.0			
	Total					46.0	23.0	21	20.0	3.0

(*Continued on p. 74*)

TABLE 31—(*Continued*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
April	Alfalfa (mature):									
	First cutting:									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	0.5			
	Hauling and storing in barn	2	2	Wagon	10 tons	1.5	2.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Cantaloupes:									
	Replanting skips and hoeing	1		Hoe	1.0 acre	0.0	25.0			
	Cultivating	1	2	Riding cultivator	8.0 acres	6.0	3.0			
	Cultivating	1	1	5-ft. spike-tooth harrow	8.0 acres	3.0	3.0			
	Cultivating	1	2	Riding cultivator	8.0 acres	6.0	3.0			
	Total					21.5	41.0	18	18.0	23.0
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature):									
	Second cutting									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1 5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	1.0			
	Hauling and stacking	2	2	Wagon	10 tons	3.0	3.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Cantaloupes:									
	Thinning and weeding	1		Hoe	1.0 acre	0 0	25.0			
	Cultivating	1	1	Walking cultivator	8.0 acres	3.0	3.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	3.0			
	Furrowing for irrigation	1	2	12-in. lister	8.0 acres	6.0	3.0			
	Irrigating	2		Shovels	6.0 acres	0.0	8.0			
	Total					18.0	51.0	23	23.0	28 0

June	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature):									
	Third cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Cantaloupes:									
	Cultivating	1	1	Walking cultivator	8.0 acres	3.0	3.0			
	Furrowing for irrigation	1	2	12-in. lister	8.0 acres	6.0	3.0			
	Irrigating (twice)	2		Shovels	6.0 acres	0.0	16.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	3.0			
	Total					19.0	34.5	26	24.0	10.5
July	Alfalfa (mature):									
	Fourth cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Cantaloupes:									
	Irrigating	2		Shovels	6.0 acres	0.0	8.0			
	Harvesting (4/5 or 3,000 crates)									
	Picking and packing (contract)	.....				.....	.....			
	Hauling from field and supervision of crew	1	2	Wagon	450 crates	14.0	14.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					22.0	30.5	26	24.0	6.5
August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Cantaloupes:									
	Harvesting (cont., 1/5 or 750 crates)									
	Picking and packing (contract)	.....				.....	.....			
	Hauling from field and supervision of crew	1	2	Wagon	450 crates	4.0	4.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total	.....				5.0	4.5	26	4 5	0.0

(*Concluded on p. 76*)

TABLE 31—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
September	Alfalfa (mature):									
	Fifth cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing ditch bottoms	2	2	12-in. plow		1.0	0.5			
	Total					9.0	9.0	25	6.5	2.5
October	Alfalfa (mature):									
	Sixth cutting (same as first cutting)					6.5	5.0			
	Cantaloupes:									
	Disking	1	2	4-ft. disk	3.2 acres	16.0	8.0			
	Total					22.5	13.0	22	12.0	1.0
	Total for year					219.0	227.0	245	152.5	74.5

TABLE 32

CALENDAR OF OPERATIONS FOR A 40-ACRE TRUCK FARM FOR THIRD YEAR OF ROTATION

(Mature alfalfa, cantaloupes, and melons)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Total					4.0	2 0	17	2.0	0.0
December	Total					0.0	0.0	16	0.0	0.0
January	Alfalfa (mature):									
	Renovating	1	3	6-ft. spring-tooth harrow	4.8 acres	9.0	3.0			
	Total					9.0	3.0	14	3.0	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Melons:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6.5			
	Disking	1	2	4-ft. disk	6.5 acres	4.0	2.0			
	Total					27.5	10.5	11	10.5	0.0
March	Cantaloupes:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	19.5	6 5			
	Disking (twice)	1	2	4-ft. disk	6.5 acres	8.0	4 0			
	Harrowing	1	3	6-ft. spring-tooth harrow	4.0 acres	9.0	3.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	8.0 acres	3.0	1.5			
	Planting	2	2	Planting sled	8.0 acres	3.0	3.0			
	Melons:									
	Disking (2 ways)	1	2	4-ft. disk	3.2 acres	8.0	4.0			
	Total					50.5	22.0	21	20.5	1.5

(Continued on p. 78)

TABLE 32—(*Continued*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
April	Alfalfa (mature):									
	First cutting									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	0.5			
	Hauling and storing in barn	2	2	Wagon	10 tons	1.5	2.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Cantaloupes:									
	Replanting skips and hoeing	1		Hoe	1.0 acre	0.0	12.5			
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Cultivating	1	1	5-ft. spike-tooth harrow	8.0 acres	1.5	1.5			
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Melons:									
	Harrowing	1	3	6-ft. spring-tooth harrow	4.0 acres	9.0	3.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	8.0 acres	3.0	1.5			
	Planting	2	2	Planting sled	8.0 acres	3.0	3.0			
	Total					29.0	31.5	18	18.0	13.5
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature):									
	Second cutting									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	1.0			
	Hauling and stacking	2	2	Wagon	10 tons	3.0	3.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			

May (*concluded*)	Cantaloupes:									
	Thinning and weeding	1		Hoe	1.0 acre	0.0	12.5			
	Cultivating	1	1	Walking cultivator	8.0 acres	1.5	1.5			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Furrowing for irrigation	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Irrigating	2		Shovels	6.0 acres	0.0	4.0			
	Melons:									
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Thinning and weeding	1		Hoe	1.0 acre	0.0	12.5			
	Cultivating	1	2	Riding cultivator	8.0 acres	3.0	1.5			
	Furrowing	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Irrigating	2		Shovels	9.0 acres	0.0	3.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Total					22.5	51.5	23	23.0	28.5
June	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature):									
	Third cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Cantaloupes:									
	Cultivating	1	1	Walking cultivator	8.0 acres	1.5	1.5			
	Furrowing	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Irrigating (twice)	2		Shovels	6.0 acres	0.0	8.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Melons:									
	Cultivating	1	1	Walking cultivator	8.0 acres	3.0	1.5			
	Furrowing	1	2	12-in. lister	8.0 acres	3.0	1.5			
	Irrigating	2		Shovels	9.0 acres	0.0	3.0			
	Dusting	1		Knapsack duster	9.0 acres	0.0	1.5			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Total					20.5	29.5	26	21.5	8.0

(*Concluded on p. 80*)

TABLE 32—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
July	Alfalfa (mature):									
	Fourth cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Cantaloupes:									
	Irrigating	2		Shovels	6.0 acres	0.0	4.0			
	Harvesting (4/5 or 1,500 crates)									
	Picking and packing (contract)									
	Hauling from field and supervision of crew	1	2	Wagon		7.0	11.5			
	Melons:									
	Irrigating	2		Shovels	9.0 acres	0.0	3.0			
	Harvesting (1/4 or 18 tons)									
	Picking	2		Picking bags	12 tons	0.0	3.0			
	Loading	1			18 tons	0.0	1.0			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					15.0	31.0	26	23.5	7.5
August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Cantaloupes:									
	Harvesting (cont., 375 crates)									
	Picking and packing (contract)	.....				.....	.....			
	Hauling from field and supervision of crew	1	2	Wagon		2.0	4.0			
	Melons:									
	Harvesting (cont., 3/4 or 57 tons)									
	Picking	2		Picking bags	12 tons	0.0	9.5			
	Loading	1			18 tons	0.0	3.5			
	Hauling to shipping point (contract)	.....				.....	.....			
	Total					3.0	17.5	26	12.5	5 0

September	Alfalfa (mature):										
	Fifth cutting (same as second cutting)						8.0	6.5			
	Irrigating	2		Shovels	18.0 acres		0.0	2.0			
	Plowing ditch bottoms	1	2	12-in. plow			1.0	0.5			
	Total						9.0	9.0	25	6.5	2.5
October	Alfalfa (mature):										
	Sixth cutting (same as first cutting)						6.5	5.0			
	Covercrop:										
	Irrigating	2		Shovels	18.0 acres		0.0	2.0			
	Disking (2 ways)	1	2	4-ft. disk	3.0 acres		8.0	4.0			
	Seeding	1		Hand broadcaster	18.0 acres		0.0	1.0			
	Harrowing	1	2	10-ft. spike-tooth harrow	13.0 acres		2.0	1.0			
	Total						16.5	13.0	22	11.0	2.0
	Total for year						205.0	220.5	245	152.0	68.5

The annual man-labor requirements of this farm for each of the 3 typical years of the rotation amount to 251½, 227, and 220½ man days of labor with an average for the 3 years of 233 man days. The yearly requirements do not vary materially from year to year. Of this total the operator can take care of 188, 152½, and 152 days respectively. Based on the 245 days a year available for field work, the operator's efficiency is 62.7 per cent, 50.8 per cent, and 50.7 per cent respectively for each of the 3 years, with a general average of 54.7 per cent. This is not a particularly high degree of efficiency. With this scheme of cropping, the amount of labor which must be hired varies from 25.2 per cent to 32.8 per cent of the total needs, with an average for the 3-year period of 29.7 per cent. This extra labor is required at intervals throughout the year ranging from ½ man day to a maximum of 28½ man days a month. During 11 of the 36 months of the rotation no hired labor is required. The irregularity of need prevents the hiring of a regular man. Reliance must, therefore, be placed upon obtaining day labor when needed. A low degree of efficiency in the use of horses results in a high cost per day of use and indicates the possibility of reducing the number of horses maintained and hiring such additional horse work as is necessary to meet the peak labor needs.

TABLE 33

NUMBER OF DAYS OPERATOR OF A 40-ACRE TRUCK FARM HAS AVAILABLE FOR ADDITIONAL WORK*

Month	First year		Second year		Third year	
	Total†	For soil work‡	Total†	For soil work‡	Total†	For soil work‡
	1	*2*	*3*	*4*	*5*	*6*
November	13.5	4.5	24.0	15.0	24.0	15.0
December	15.5	5.5	26.0	16.0	26.0	16.0
January	13.5	1.5	18.0	6.0	23.0	11.0
February	13.5	0.5	13.5	0.5	13.5	0.5
March	5.0	0.0	6.0	1.0	5.5	2.5
April	8.0	0.0	8.0	0.0	8.0	0.0
May	3.0	0.0	3.0	0.0	3.0	0.0
June	7.5	7.5	6.0	6.0	4.5	4.5
July	0.0	0.0	2.0	2.0	2.5	2.5
August	10.0	10.0	21.5	21.5	13.5	13.5
September	14.0	13.0	19.5	18.5	19.5	18 5
October	18.5	14.5	14.0	10.0	15.0	11.0
Total	122.0	57.0	157.5	96.5	158.0	95.0

* Labor requirements of this cropping plan are based on a 9-hour work day.

† Time available for additional work is the difference between the time needed for carrying on the present organization and a 26-day month, except February, which is a 24-day month. It might be used for work away from the farm, for types of work not limited by climatic conditions, such as the handling of livestock, pruning of trees, etc., or for soil work to the extent given in columns 2, 4, and 6.

‡ Of the total number of days available for additional work the figures in columns 2, 4, and 6 show the amount each month which can be used in performing additional soil operations under average weather conditions.

An examination of these calendars shows a fairly even distribution of the operator's labor throughout the 3 years. There are 2 months during the 3 years when no work occurs, other than the usual chores. There is but 1 month, likewise, during the 3 years, when the operator is fully employed. The rest of the time he is kept busy at productive labor for a varying number of days each month, ranging from 2 to 24 days a month. As a result there is a certain amount of spare time which could be utilized for additional work. The operator's free time is shown in table 33.

The data given in table 33 does not necessarily reflect a criticism of this form of organization. The primary purpose of this table is to point out to the operator the possibilities for making further use of his time than work on this farm now permits. Moreover, the data may also indicate that a 40-acre farm so utilized is too small if a high degree of efficiency is to be attained and an increased net income secured.

FINANCIAL RESULTS

To test the financial outcome of the cropping plan devised for this farm, it is necessary to compile data on production and costs and calculate net income for each of the 3 typical years of the rotation. These data together with the items of investment required for this form of farm organization are next presented.

Investment Items.—The items of investment required to establish and fully equip this farm are as follows:

Land: 40 acres; leveled, checked, and ditched; supplied with water by the Turlock Irrigation District

Buildings and structures:
- Farm dwelling, septic tank, and garage. These items, though necessary, are not deemed a part of the farm business.
- Horse barn, with storage for hay and implements
- Water tank, tower, pump, motor, piping and fittings for lifting and distributing water to house and livestock
- Horse corral
- Cantaloupe packing shed
- 4 canal headgates
- 76 outlet boxes from ditches to checks

Motive power:
- 3 horses
- Automobile (primarily for personal use and not included as a part of the farm business)

Implements and machinery:
- 14-in. sulky plow
- 12-in. walking plow
- 12-in. lister
- 6-ft. spring-tooth harrow
- 10-ft. spike-tooth harrow
- 4-ft. single-disk harrow
- 10-ft. plank drag
- 5-ft. mower
- 10-ft. rake
- Riding cultivator
- Walking cultivator
- Transplanter
- Wagon
- Hay stacker
- Sweet-potato plow
- Fresno scraper
- Melon-planting sled
- 2 knapsack dusters
- 6 melon-picking bags
- Jab planter
- Eveners, doubletrees, and neck yokes

Horse equipment:
- 1½ sets of work harness
- 3 horse collars
- 3 halters and tie chains
- Curry comb, brush, barn broom, manure fork, hoof rasp, clippers, etc.

Tools, hand implements, and minor equipment:
- 4 metal tappoons (for use in irrigating)
- Carpenter's tools
- Carpenter's vise
- Small set of mechanic's tools
- Mechanic's vise
- Pick, shovel, hoes, crowbar, axe, grindstone, etc.
- Rubber boots, gopher traps, etc.

Statement of Production.—The total production of crops, amounts reserved for farm use, and balances available for sale during each of the 3 years of the rotation are given in table 34.

TABLE 34

PRODUCTION AND AMOUNTS OF CROPS AVAILABLE FOR SALE ON A 40-ACRE TRUCK FARM

	First year				Second year		Third year		
	Alfalfa hay	Canta-loupes	Barley hay	Melons	Alfalfa hay	Canta-loupes	Alfalfa hay	Canta-loupes	Melons
	tons	*crates*	*tons*	*tons*	*tons*	*crates*	*tons*	*crates*	*tons*
Yields per acre	2	150	2	6	5.0	150	5.0	150	6
Total production	25	1,875	25	75	62.5	3,750	62.5	1,875	75
Reserved for farm use	.....	.....	25*	.....	11.0†	.....	18.0	.....	.....
Available for sale	25	1,875	.....	75	51.5	3,750	44.5	1,875	75

* 18 tons used, balance stored for future use so that no barley hay needs to be raised in third year.
† Amount reserved for horse feed.

Financial Statement.—The unit factors involved in production and maintenance of this farm and the financial results for each of the 3 typical years of the crop rotation under stated conditions of selling prices of products and costs of the factors of production, are given in detail in table 35.

TABLE 35

Income and Expenses of a 40-Acre Truck Farm

Annual gross income

	First year	Second year	Third year
Alfalfa at $12.00 a ton*	$ 300.00	$ 618.00	$ 534.00
Cantaloupes at $1.00†	1,875.00	3,750.00	1,875.00
Honey Dew melons at $16.00	1,200.00	.....	1,200.00
Total	$3,375.00	$4,368.00	$3,609.00

Annual expenses

	First year	Second year	Third year
Hired labor at $2.25 a day of 9 hours‡	$ 142.88	$ 167.63	$ 154.13
Materials and supplies:			
Seed			
Melilotus indica, 250 pounds at $0.06	.....	.....	15.00
Vetch, 188 pounds at $0.08	.....	.....	15.04
Cantaloupe at $1.50 a pound¶	57.00	112.50	57.00
Honey Dew melon at $1.50 a pound	28.50	.....	28.50
Alfalfa at $0.20 a pound	50.00	.....	.....
Barley at 1¼ cents a pound	10.94	.....	.....
Lath furrow pipes, 1,650 at $0.05	82.50	82.50	82.50
Dusting material:			
Nicodust at $0.20 a pound	50.00	50.00	50.00
Cantaloupe crates at $0.17†	318.75	637.50	318.75
Contract work:			
Baling alfalfa hay at $2.50 a ton*	62.50	128.75	111.25
Making crates, picking and packing cantaloupes at $0.20 a crate†	375.00	750.00	375.00
Hauling alfalfa hay to shipping point at $1.25 a ton*	31.25	64.38	55.63
Hauling cantaloupes to shipping point at $0.03 a crate†	56.25	112.50	56.25
Hauling melons to shipping point at $1.00 a ton	75.00	.....	75.00
Renting extra horses at $1.00 a day	3.00	.....	.....
Irrigation water at $4.50 an acre for 40 acres	180.00	180.00	180.00
Electricity, annual pro rata charge	1.60	1.60	1.60
Repairs and upkeep of equipment:			
Buildings, 5.0 per cent of $1,118.00 (Dwelling, garage, and septic tank not included)	55.90	55.90	55.90
Irrigation structures, 2.4 per cent of $370.00	8.88	8.88	8.88
Implements and machinery, 3.2 per cent of $930.00	29.76	29.76	29.76
Harness, collars, halters, and tie chains, 1.0 per cent of $94.00	0.94	0.94	0.94
Small tools, barn, and minor equipment, 1.3 per cent of $167.00	2.17	2.17	2.17
Domestic pumping plant, 0.5 per cent of $548.00	2.74	2.74	2.74
Veterinary expense	10.00	10.00	10.00
Taxes:			
Land in alfalfa	40.38	40.38	40.38
Land in truck crops, farmstead, lanes, and ditches	106.10	106.10	106.10
Buildings (based on average value)	7.60	7.60	7.60
Work animals (based on average value)	4.56	4.56	4.56
Implements and machinery (based on average value)	7.07	7.07	7.07
Hay	0.32	0.32	0.32

* First year, 25 tons; second year, 51.5 tons; third year, 44.5 tons.
† First year, 1,875 crates; second year, 3,750 crates; third year, 1,875 crates.
‡ First year, 63.5 days; second year, 74.5 days; third year, 68.5 days.
¶ First year, 38 pounds; second year, 75 pounds; third year, 38 pounds.

TABLE 35—(*Concluded*)

Annual expenses—(*Concluded*)

	First year	Second year	Third year
Depreciation of equipment:			
Buildings, 5.0 per cent of $1,118.00 (dwelling, garage, and septic tank not included)	$ 55.90	$ 55.90	$ 55.90
Irrigation structures, 11.8 per cent of $370.00	43.66	43.66	43.66
Work horses, 10.0 per cent of $375.00	37.50	37.50	37.50
Implements and machinery, 10.7 per cent of $930.00	99.51	99.51	99.51
Harness, collars, halters, and tie chains, 16.6 per cent of $94.00	15.60	15.60	15.60
Small tools, barn, and minor equipment, 11.1 per cent of $167.00	18.54	18.54	18.54
Domestic pumping plant 7.4 per cent of $548.00	40.55	40.55	40.55
Insurance:			
Horse barn, 1.3 per cent of $225.00	2.92	2.92	2.92
Hay in barn, insured for 6 months, annual premium 2.5 per cent of cash value‖	2.97	2.14	2.14
Employers' liability, 2.9 per cent of pay roll	4.14	4.86	4.47
Total	$2,122.88	$2,884.96	$2,172.86

Net farm income

	First year	Second year	Third year	Average for 3 years
Gross income	$3,375.00	$4,368.00	$3,609.00	$3,784.00
Expenditures	2,122.88	2,884.96	2,172.86	2,393.57
Net farm income	$1,252.12	$1,483.04	$1,436.14	$1,390.43

‖ On value of $9.50 per ton, first year, 25 tons; second year, 18 tons; third year, 18 tons.

With the yields, selling prices, and costs used in this test, the annual net farm income ranges from $1,252.12 to $1,483.04 and averages $1,390.43 per year for the 3-year period. The moderate amount of diversification included in this cropping program is desirable as it tends to reduce the risk of total failure and to provide for a relatively stable net income from year to year.

POSSIBLE CHANGES IN FINANCIAL RESULTS

The average annual net income, under the conditions stated, is not high, and if the operator should set as the minimum a net income of $1,800.00 a year to maintain his standard of living, improvement must be sought in one or more ways. Suggestions for ways and means of increasing the net income of this farm are: (*a*) an increase in the price obtainable for the commodities produced for sale, (*b*) an increase in yields, (*c*) a change in the cropping program, (*d*) addition of one or more enterprises, or (*e*) an increase in the size of business.

Effect of Increase in Selling Prices.—To gain the additional $409.57 required to bring the net farm income up to $1,800.00, prices would have to advance about 10.8 per cent. Instead of $1.00 a crate for cantaloupes, $16.00 a ton for Honey Dew melons, and $12.00 a ton for alfalfa hay as used in the preceding test, the prices received by the grower would have to be increased to $1.11 for cantaloupes, $17.73 for melons, and $13.30 for alfalfa hay. The individual operator is forced to accept the market price prevailing at the time when his crop is ready for harvest, or in the case of nonperishable commodities, when he is forced to liquidate his stocks in order to obtain cash. The operator's control over selling prices is therefore confined primarily to the success which he attains in producing products of high quality and to the selection of a selling agent who will return to him the maximum amount possible under the market conditions prevailing at the time. However, if the price history of the past few years (1922–23 to 1930–31) should repeat itself these products of the Turlock area would command prices considerably higher than those used in the financial test of the farm. It is not beyond the realm of possibility.

Effect of Increased Yields.—None of the yields used in calculating these data are exceptionally high; rather they may be termed usual yields. Increase in amount of production is both possible and feasible. Growers of these crops on the better lands and under competent management are obtaining per-acre yields of 3½ tons of alfalfa (year of seeding), 8 tons of alfalfa (mature stands), 250 crates of cantaloupes, and 9 tons of melons.

Though these are good yields they are by no means exceptional. Exceptional yields run as high as 400 standard crates of cantaloupes per acre, 12 tons of Honey Dew melons, and 10 tons of alfalfa per acre per season from mature stands. There appears to be room for considerable improvement in the yields for farms similar to the one described above and such improvement will have a beneficial result upon the final net farm income obtainable.

With the selling prices as given in table 35 and expenditures adjusted to cover the increased production, the net income received from this farm when good yields are obtained during each of the 3 years of the rotation is shown in table 36.

The average annual net farm income of $1,390.43 (table 35), obtained when only *usual* yields are produced, is increased to $3,008.09 by producing *good* yields. Thus an average increase in yields of slightly more than 60 per cent increases the net farm income 117 per cent, with selling prices and costs remaining the same.

TABLE 36

FINANCIAL STATEMENT OF A 40-ACRE TRUCK FARM WHEN GOOD YIELDS ARE OBTAINED

	First year	Second year	Third year	Average for 3 years
Gross income	$5,450.00	$7,318.00	$5,889.00	$6,219.00
Expenditures	2,730.70	4,025.57	2,876.45	3,210.91
Net farm income	$2,719.30	$3,292.43	$3,012.55	$3,008.09

Changing the Cropping Program.—Farmers' experiences in the Turlock area indicate that the rotation plan used in connection with this farm is that which is required in order to maintain the crop-producing power of the land. Therefore, so far as our present knowledge goes, no change in the general plan as formulated for this farm appears feasible.

The particular crops selected for this rotation are merely suggestive of one of the several combinations possible with the large number of field and truck crops adaptable to this area. Whenever conditions warrant, it is perfectly feasible to substitute in the proper place in the rotation, any one of the several other crops adapted to the area and to the particular conditions of the farm. For example, under some conditions sweet potatoes may be substituted for cantaloupes. Where this is possible and contemplated by the operator, the proposed change should be tested in accordance with the methods described in this publication. Suppose the operator wants to know what effect a price of $1.50 per packed crate for sweet potatoes would have upon his net farm income as compared with $1.00 per packed crate of cantaloupes, should he substitute 25 acres of sweet potatoes for 25 acres of cantaloupes. He asks two questions: "At this price for sweet potatoes and with a yield of 100 crates of 75 pounds net per acre, will my net income be greater or less than I would obtain with cantaloupes at $1.00 per packed crate?" and "What price must I get for sweet potatoes to give me the same net income that I could get from cantaloupes at $1.00 per packed crate?"

The answers to these questions may be obtained first by drawing up a calendar of operations and, secondly, by constructing a financial statement. The results of these procedures are given in tables 37 and 38.

Analysis of the calendar of operations shows that this combination of crops provides a rather full schedule of work for the operator from February to October, totaling 214½ man days of productive work for the year, or an efficiency of 87.5 per cent. A total of 213 man days of labor or approximately 50 per cent of the total required labor must be hired. This amounts to a considerable increase over the requirements when cantaloupes are grown during this year of the rotation, but direct

comparison cannot be made with the figures given since the cantaloupe harvest was shown as a contract operation, a customary practice in the area, rather than on the basis of hired day labor.

To take care of peak needs extra horses are required in addition to those owned by the operator during February and April. In February it will be necessary to hire a total of 51 horse days or to contract the plowing and hire horses for the extra 10 horse days required. In April an extra horse is required for 8 days in order to complete the harvest of the first cutting of alfalfa and in the preparation of the land for sweet potatoes.

Items of equipment required in addition to those listed under "Investment Items" (pages 83, 84) are as follows:

12-in. lister
6-ft. plank drag
Sweet potato plow
Transplanter

The financial results of the year's operation are shown in table 38. The gross income and expenses from the 12½ acres of mature alfalfa remain the same as shown in table 35, second year of the rotation. Income and expenses resulting from growing the 25 acres of sweet potatoes are shown in detail.

The financial statement as given in table 38 provides a basis for answering the two questions propounded in an earlier paragraph. The answer to the first question is, obviously, that sweet potatoes during this year of the rotation, under the conditions stated, provide the greater net income by $631.95.

The second question, "What price for sweet potatoes corresponds to $1.00 a crate for cantaloupes?" can likewise now be answered. Since 2,500 crates of sweet potatoes produce a net farm income greater by $631.95 than obtained from cantaloupes (alfalfa hay receipts remaining constant and hence ignored) the returns from sweet potatoes can drop by this amount or approximately 25 cents a crate and still equal the returns from cantaloupes, or a price of about $0.25 less a crate will produce a corresponding amount of income. This means a selling price of $1.25 a crate of 75 pounds net from sweet potatoes will produce the same net income as that obtainable when cantaloupes sell at $1.00 a crate.

Additional Enterprises.—Use of the available time of the operator in connection with an additional enterprise may well be suggested. Though worthy of consideration in connection with a farm such as this, no at-

TABLE 37

CALENDAR OF OPERATIONS FOR A 40-ACRE TRUCK FARM

(Sweet potatoes, 25 acres, are substituted for cantaloupes; mature alfalfa, 12½ acres)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
November	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Sweet potatoes:									
	Disking (twice)	1	2	4-ft. disk	6.5 acres	16.0	8.0			
	Total					20.0	10.0	17	10.0	0.0
December	Total					0.0	0.0	16	0.0	0.0
January	Alfalfa (mature):									
	Renovating	1	3	6-ft. spring-tooth harrow	4.8 acres	9.0	3.0			
	Total					9.0	3.0	14	3.0	0.0
February	Plowing farm ditches	1	2	12-in. plow		4.0	2.0			
	Sweet potatoes:									
	Plowing	1	3	14-in. sulky plow	1.9 acres	40.5	13.5			
	Disking (twice)	1	2	4-ft. disk	6.5 acres	16.0	8.0			
	Growing plants in hot bed (750 ft. by 6 ft.)									
	Plowing	2	2	12-in. plow		0.5	0.5			
	Scraping	2	2	5-ft. Fresno scraper		2.0	2.0			
	Shoveling	1		Shovel		0.0	2.0			
	Hauling manure (30 tons)	2	2	Wagon	10 tons	6.0	6.0			
	Spreading manure and sand	1		Shovel		0.0	2.0			
	Hauling seed stock and covering	2	2	Wagon		15.0	15.0			
	Irrigating (2 times)	1			0.5 man day per time	0.0	1.0			
	Total					84.0*	52.0	11	22.0	30.0

March	Sweet potatoes:									
	Irrigating hot bed (3 times)	1			0.5 man day per time	0.0	1.5			
	Harrowing (twice)	1	3	6-ft. spring-tooth harrow	4.0 acres	37.5	12.5			
	Harrowing	1	2	10-ft. spike-tooth harrow	8.0 acres	6.0	3.0			
	Total					43.5	17.0	21	17.0	0.0
April	Alfalfa (mature):									
	First cutting									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	0 5			
	Hauling and storing in barn	2	2	Wagon	10 tons	1.5	2.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Sweet potatoes:									
	Ridging	1	2	12-in. plow	2 4 acres	21.0	10.5			
	Smoothing	1	2	6-ft. drag	3.3 acres	16.0	8.0			
	Transplanting (½ of acreage)									
	Pulling plants	1			1.3 acres	0.0	9.5			
	Planting	3	2	Transplanter	2.0 acres	12.0	18.0			
	Cultivating	1	2	Walking cultivator	4.0 acres	6.0	3.0			
	Total					61.5†	56.0	18	23.0	33.0
May	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature):									
	Second cutting									
	Mowing	1	2	5-ft. mower	8.0 acres	3.0	1.5			
	Raking	1	2	12-ft. rake	13.0 acres	2.0	1.0			
	Shocking	1		Pitchfork	10 tons	0.0	1.0			
	Hauling and stacking	2	2	Wagon	10 tons	3.0	3.0			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			

(*Concluded on p. 92*)

*51 horse days hired. †8 horse days hired.

TABLE 37—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per 9-hour day	Labor requirements		Available days for soil work	Amount operator can do, man days	Hired labor, man days
		Men	Horses	Implements		Horse days	Man days			
May (*concluded*)	Sweet potatoes:									
	Transplanting (½ of acreage)									
	Pulling plants	1			1.3 acres	0.0	9.5			
	Planting					13.0	19.5			
	Cultivating	1	2	Walking cultivator	4.0 acres	7.0	3.5			
	Hoeing	1		Hoe	1.5 acre	0.0	17.0			
	Total					36.0	58.5	23	24.5	34.0
June	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Alfalfa (mature):									
	Third cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Sweet potatoes:									
	Irrigating	2		Shovels	4.5 acres	0.0	11 0			
	Cultivating (twice)	1	2	1-row cultivator	4.0 acres	25.0	12.5			
	Total					35.0	33.0	26	25.0	8.0
July	Alfalfa (mature):									
	Fourth cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Sweet potatoes:									
	Irrigating and cultivating (same as June)					25.0	23.5			
	Total					33.0	32.0	26	24.0	8.0

August	Plowing ditch bottoms	1	2	12-in. plow		1.0	0.5			
	Sweet potatoes:									
	Harvesting (1/3 of crop)									
	Cutting tops	3			4.0 acres	0.0	6.0			
	Plowing out	1	2	Sweet-potato plow	4.0 acres	4.0	2.0			
	Picking up, rough sorting, piling, and covering (gross yield, 9,500 lbs. per acre)	3			7,500 lbs.	0.0	31.5			
	Sorting, grading, packing, and selling 1/3 of crop	1			100 crates	0.0	10.5			
	Total					5.0	50.5	26	26.5	24.0
September	Alfalfa (mature):									
	Fifth cutting (same as second cutting)					8.0	6.5			
	Irrigating	2		Shovels	18.0 acres	0.0	2.0			
	Plowing ditch bottoms	2	2	12-in. plow		1.0	0.5			
	Sweet potatoes:									
	Harvesting (2/3 of crop)									
	Cutting tops	3			4.0 acres	0.0	13.0			
	Plowing out	1	2	Sweet-potato plow	4.0 acres	8.0	4.0			
	Picking up, rough sorting, and piling	3			7,500 lbs.	0.0	63.5			
	Sorting, packing, and selling (1/3 of crop)	1			100 crates	0.0	10.5			
	Total					17.0	100.0	25	25.0	75.0
October	Alfalfa (mature)									
	Sixth cutting (same as first cutting)					6.5	5.0			
	Sweet potatoes:									
	Sorting, packing, and selling (1/3 of crop)	1			100 crates	0.0	10.5			
	Total					6.5	15.5	22	14.5	1.0
	Totals for year					350.5‡	427.5	245	214.5	213.0

*51 horse days hired. †8 horse days hired. ‡Includes 59 horse days hired.

TABLE 38

INCOME AND EXPENSES WHEN SWEET POTATOES ARE SUBSTITUTED FOR CANTALOUPES DURING SECOND YEAR OF ROTATION ON A 40-ACRE TRUCK FARM

Annual gross income	
Alfalfa (from table 35)	$ 618.00
Sweet potatoes, 2,500 crates at $1.50	3,750.00
Sweet potato tops sold for feed, 37½ tons at $5.00	187.50
Cull potatoes for stock feed, 25 tons at $4.00	100.00
Total	$4,655.50
Annual expenses	
Hired labor 213 days at $2.25 per 9-hour day	$ 479.25
Materials and supplies:	
Sweet potato seed, 5 tons at $60.00	300.00
Manure for seed bed, 30 tons, of which 25 tons must be purchased at $1.00 a ton	25.00
Sweet potato crates, 2,500 at $0.21	525.00
Contract work:	
Baling hay (from table 35)	128.75
Hauling alfalfa hay to shipping point (from table 35)	64.38
Hauling sweet potatoes to shipping point, 2,500 crates weighing 100 tons gross at $1.50 a ton	150.00
Hire of additional horses, 59 horse days at $1.00	59.00
Irrigation water (from table 35)	180.00
Electricity (from table 35)	1.60
Repairs and upkeep of equipment (from table 35)	100.39
On sweet potato equipment, 4 per cent of $173.00	6.92
Veterinary expense	10.00
Taxes (from table 35)	166.03
On sweet potato equipment	0.13
Depreciation of equipment (from table 35)	311.26
Sweet potato equipment, 8 per cent of $173.00	13.84
Insurance:	
Horse barn and hay (from table 35)	5.06
Employers' liability, 2.9 per cent of pay roll	13.90
Total expenses	$2,540.51
Net farm income	
Gross income	$4,655.50
Expenditures	2,540.51
Net farm income	$2,114.99

tempt is here made to show the effect on the net farm income by adding a few cows or a flock of poultry—since the manner of testing has already been worked out in connection with two of the other farms. Anyone interested will find there a full account of the method of procedure, data on production, expenditures, and added investment for testing the financial feasibility of such a plan.

Increasing the Size of Business.—The calendar of operations (tables 30, 31, and 32) for the original cropping plan indicates that a man operating a 40-acre truck farm such as this is not overworked. There is an opportunity for him to farm additional land, provided that in so doing he is able to proceed as economically and conservatively with the work on the home farm. The equipment can handle more land than the 40-acre unit comprising this farm with the exception that more work animals would be required. Of course more help must be hired, more financing arranged, and a wider market outlet sought for the increased production. The expanding of the business does, however, hold definite possibilities.

ANALYSIS AND FINDINGS OF A 40-ACRE DAIRY FARM

This 40-acre dairy farm is utilized for the production of feed for dairy cows, the product of which is sold as whole milk for manufacturing purposes. The cropping program, designed to produce a continuous supply and the maximum amount of feed, consists of a 9-year rotation of alfalfa, 6 years, followed by 3 years of double-cropping to barley and vetch for winter pasture and Sudan grass for summer pasture.

Three fields of 12½ acres each are used for the cropping plan; the balance of the acreage (2½ acres) is utilized by the farmstead, ditches, and lanes. One field is planted to alfalfa every third year and a like acreage plowed out thereby maintaining two-thirds of the cropped land in alfalfa. The rotation of crops under this 3-field system is shown in table 39.

TABLE 39

Rotation of Crops on a 40-Acre Dairy Farm

Year of rotation	Field 1	Field 2	Field 3
1	Alfalfa, new seeding	Alfalfa	Annual crops
2	Alfalfa	Alfalfa	Annual crops
3	Alfalfa	Alfalfa	Annual crops
4	Alfalfa	Annual crops	Alfalfa, new seeding
5	Alfalfa	Annual crops	Alfalfa
6	Alfalfa	Annual crops	Alfalfa
7	Annual crops	Alfalfa, new seeding	Alfalfa
8	Annual crops	Alfalfa	Alfalfa
9	Annual crops	Alfalfa	Alfalfa

When fully established, the acreages of crops for the first year of the rotation are alfalfa (new seeding), 12½ acres; mature alfalfa, 12½ acres; and annual pasture crops 12½ acres. During the second and third

TABLE 40

CALENDAR OF OPERATIONS FOR A 40-ACRE DAIRY FARM FOR FIRST YEAR OF ROTATION

(Seeded alfalfa, mature alfalfa, and annual pasture crops)

Month	Crop operations	Crew and equipment			Rate of work per hour	Crop labor requirements		Dairy labor (feeding, milking, and care of cows and equipment)		Total labor requirements		Available days, for soil work	Amount operator can do, man day of 12 hours	Hired labor, man day of 9 hours
		Men	Horses	Implements		Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours			
November	Plowing farm ditches	1	2	12-in. plow		36.0	18.0	27.0	180.0					
	Total					36.0	18.0	27.0	180.0	63.0	198.0	17	16.5	9.0
December	Alfalfa (new seeding):													
	Disking	1	2	4-ft. disk	0.7 acre	36.0	18.0							
	Plowing levees	1	2	12-in. plow	1.5 acres	18.0	9.0							
	Checking and leveling	1	4	5-ft. Fresno scraper	0.5 acre	100.0*	25.0							
	Plank dragging	1	2	8-ft. plank drag	0.7 acre	36.0	18.0							
	Setting outlet boxes	2			0.5 acre	0.0	50.0							
	Total					190.0*	120.0	27.0	188.0	217.0*	308.0	16	24.0	2.5
January	Alfalfa (new seeding):													
	Spreading manure, 12 tons per acre	1	2	Manure spreader	1-1/3 tons	226.0	113.0							
	Alfalfa (mature):													
	Renovating	1	3	6-ft. spring-tooth harrow	0.5 acre	75.0	25.0							
	Total					301.0	138.0	27.0	188.0	328.0	326.0	14	23.0	5.5
February	Alfalfa (new seeding):													
	Plowing	1	3	14-in. sulky plow	0.2 acre	189.0	63.0							
	Plowing farm ditches	1	2	12-in. plow		36.0	18.0							
	Total					225.0	81.0	27.0	168.0	252.0	249.0	11	19.5	1.5

March	Alfalfa (new seeding):												
	Harrowing (2 ways)	1	3	6-ft. spring-tooth harrow	0.5 acre	75.0	25.0						
	Seeding	2	2	Wagon and broadcaster	3.0 acres	9.0	9.0						
	Harrowing	1	2	10-ft. spike-tooth harrow	1.5 acres	18.0	9.0						
	Total					102.0	43.0	27.0	188.0	129.0	231 0	21	19.0	0.5
April	Alfalfa (new seeding):												
	Clipping	1	2	5-ft. mower	1.0 acre	26 0	13.0						
	Irrigating	2		Shovels	2.0 acres	0.0	13.0						
	Alfalfa (mature):												
	First cutting												
	Mowing	1	2	5-ft. mower	1.0 acre	26.0	13.0						
	Raking	1	2	12-ft. rake	1.5 acres	18.0	9.0						
	Shocking	1		Pitchfork	1 ton	0.0	7.0						
	Hauling and stacking	2	2	Wagon	1 ton	14.0	14.0						
	Irrigating	2		Shovels	2.0 acres	0.0	13.0						
	Winter pasture:												
	Irrigating	2		Shovels	2.0 acres	0.0	13.0						
	Total					84.0	95 0	27.0	180.0	111.0	275.0	18	21.0	2.5
May	Alfalfa (new seeding):												
	First cutting												
	Mowing	1	2	5-ft. mower	1.0 acre	26.0	13.0						
	Raking	1	2	12-ft. rake	1.5 acres	18.0	9.0						
	Shocking	1		Pitchfork	1 ton	0.0	4.0						
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0						
	Alfalfa (mature):												
	Second cutting												
	Mowing	1	2	5-ft. mower	1.0 acre	26.0	13.0						
	Raking	1	2	12-ft. rake	1.5 acres	18.0	9.0						
	Shocking	1		Pitchfork	1 ton	0.0	13 0						
	Hauling and stacking	2	2	Wagon	1 ton	26.0	26.0						
	Irrigating	2		Shovels	2.0 acres	0.0	13.0						

(*Concluded on p. 98*)

* Includes 25 horse hours hired.

TABLE 40—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per hour	Crop labor requirements		Dairy labor (feeding, milking, and care of cows and equipment)		Total labor requirements		Available days, for soil work	Amount operator can do, man day of 12 hours	Hired labor, man day of 9 hours
		Men	Horses	Implements		Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours			
May (*concluded*)	Summer pasture:													
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Disking (2 ways)	1	2	4-ft. disk	0.35 acre	72.0	36.0							
	Harrowing	1	2	10-ft. spike-tooth harrow	1.5 acres	18.0	9.0							
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Total					220.0	166.0	27 0	188.0	247.0	354.0	23	27.0	3.5
June	Alfalfa (new seeding):													
	Hauling and stacking	2	2	Wagon	1 ton	9.0	9.0							
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Alfalfa (mature):													
	Third cutting (same as second cutting)					70.0	61.0							
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Summer pasture:													
	Seeding	2	2	Wagon and broadcaster	3.3 acres	9.0	9.0							
	Harrowing	1	2	Spike-tooth harrow	1.5 acres	18.0	9.0							
	Total					114.0	118.0	27.0	180.0	141.0	298.0	26	22.0	4.0
July	Alfalfa (new seeding):													
	Second cutting													
	Mowing	1	2	5-ft. mower	1.0 acre	26.0	13.0							
	Raking	1	2	12-ft. rake	1.5 acres	18.0	9.0							
	Shocking	1		Pitchfork	1 ton	0.0	9.0							
	Hauling and stacking	2	2	Wagon	1 ton	18.0	18.0							
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Alfalfa (mature):													
	Fourth cutting (same as second cutting)					70.0	61.0							
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Summer pasture:													

August	Alfalfa (new seeding):													
	Third cutting (same as second cutting)					62.0	49.0							
	Irrigating	2		Shovels		0.0	13.0							
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Summer pasture:													
	Irrigating (twice)	2		Shovels	2.0 acres	0.0	26.0							
	Total					70.0	92.0	25.0	186.0	95.0	278.0	26	21.0	3.0
September	Alfalfa (new seeding):													
	Fourth cutting (same as first cutting)					53.0	35.0							
	Alfalfa (mature):													
	Fifth cutting (same as second cutting)					70.0	61.0							
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Plowing ditch bottoms					8.0	4.0							
	Summer pasture:													
	Irrigating (twice)	2		Shovels	2.0 acres	0.0	26.0							
	Total					131.0	139.0	27.0	180.0	158.0	319.0	25	23.0	4.5
October	Alfalfa (new seeding):													
	Irrigating	2		Shovels	2.0 acres		13.0							
	Alfalfa (mature):													
	Sixth cutting (same as first cutting)					58.0	43.0							
	Winter pasture:													
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Plowing	1	3	14-in. sulky plow	0.2 acre	189.0	59.0							
	Harrowing	1	3	6-ft. spring-tooth harrow	0.5 acre	75.0	25.0							
	Seeding	2	2	Wagon and broadcaster	3.0 acres	9.0	9.0							
	Harrowing	1	2	Spike-tooth harrow	1.5 acres	18.0	9.0							
	Total					349.0	171.0	27.0	188.0	376.0	359.0	22	27.0	4.5
	Total for year					1,929.0*	1,330.0	320.0	2,200.0	2,274.0*	3,530.0	245	267.0	37.0

* Includes 25 horse hours hired.

TABLE 41

CALENDAR OF OPERATIONS FOR A 40-ACRE DAIRY FARM FOR SECOND YEAR OF ROTATION*

(Mature alfalfa and annual pasture crops)

Month	Crop operations	Crew and equipment			Rate of work per hour	Crop labor requirements		Dairy labor (feeding, milking, and care of cows and equipment)		Total labor requirements		Available days, for soil work	Amount operator can do, man day of 12 hours	Hired labor, man day of 9 hours
		Men	Horses	Implements		Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours			
November	Plowing farm ditches	1	2	12-in. plow		36.0	18.0							
	Total					36.0	18.0	27.0	180 0	63.0	198.0	17	16.5	0.0
December	Total					0.0	0 0	27.0	188.0	27.0	188.0	16	16 0	0.0
January	Alfalfa (mature):													
	Renovating	1	3	6-ft. spring-tooth harrow	0.5 acre	150.0	50.0							
	Total					150.0	50.0	27 0	188 0	177.0	238.0	14	20.0	0.0
February	Plowing farm ditches	1	2	12-in. plow		36.0	18.0							
	Total					36.0	18.0	27.0	168.0	63.0	186.0	11	15.5	0.0
March	Total					0 0	0 0	27 0	188 0	27 0	188 0	21	16 0	0 0
April	Alfalfa (mature):													
	First cutting:													
	Mowing	1	2	5-ft. mower	1.0 acre	50 0	25 0							
	Raking	1	2	12-ft. rake	1.5 acres	34.0	17.0							
	Shocking	1		Pitchfork	1 ton	0.0	13.0							
	Hauling and stacking	2	2	Wagon	1 ton	25 0	25.0							
	Irrigating	2		Shovels	2.0 acres	0.0	26.0							
	Winter pasture:													
	Irrigating	2		Shovels	2.0 acres	0 0	13.0							
	Total					109.0	119.0	27.0	180.0	136.0	299.0	18	22.0	4.0

May	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Alfalfa (mature):													
	Second cutting													
	Mowing	1	2	5-ft. mower	1.0 acre	50.0	25.0							
	Raking	1	2	12-ft. rake	1.5 acres	34.0	17.0							
	Shocking	1		Pitchfork	1 ton	0.0	25.0							
	Hauling and stacking	2	2	Wagon	1 ton	50.0	50.0							
	Irrigating	2		Shovels	2.0 acres	0.0	26.0							
	Summer pasture:													
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Disking (2 ways)	1	2	4-ft. disk	0.35 acre	72.0	36.0							
	Harrowing	1	2	10-ft. spike-tooth harrow	1.5 acres	18.0	9.0							
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Total					240.0	209.0	27.0	188.0	267.0	397.0	23	27.0	8.0
June	Alfalfa (mature):													
	Third cutting (same as second cutting)					134.0	117.0							
	Irrigating	2		Shovels	18.0 acres	0.0	26.0							
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Summer pasture:													
	Seeding	2	2	Wagon and broadcaster	3.0 acres	9.0	9.0							
	Harrowing	1	2	10-ft. spike-tooth harrow	1.5 acres	18.0	9.0							
	Total					169.0	165.0	27.0	180.0	196.0	345.0	26	25.0	5.0
July	Alfalfa (mature):													
	Fourth cutting (same as second cutting)					134.0	117.0							
	Irrigating	2		Shovels	18.0 acres	0.0	26.0							
	Summer pasture:													
	Irrigating	2		Shovels	2.0 acres	0.0	13.0							
	Total					134.0	156 0	25.0	186.0	159 0	342.0	26	24.5	5.0

(*Concluded on p. 102*)

* Third year of rotation same as the second year.

TABLE 41—(*Concluded*)

Month	Crop operations	Crew and equipment			Rate of work per hour	Crop labor requirements		Dairy labor (feeding, milking, and care of cows and equipment)		Total labor requirements		Available days, for soil work	Amount operator can do, man day of 12 hours	Hired labor, man day of 9 hours
		Men	Horses	Implements		Horse hours	Man hours	Horse hours	Man hours	Horse hours	Man hours			
August	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Summer pasture:													
	Irrigating (twice)	2		Shovels	2.0 acres	0.0	26.0							
	Total					8.0	30.0	25.0	186.0	33.0	216.0	26	17.0	1.0
September	Alfalfa (mature):													
	Fifth cutting (same as second cutting)					134 0	117.0							
	Irrigating	2		Shovels	18.0 acres	0.0	26.0							
	Plowing ditch bottoms	1	2	12-in. plow		8.0	4.0							
	Summer pasture:													
	Irrigating (twice)	2		Shovels	2.0 acres	0.0	26.0							
	Total					142.0	173.0	27.0	180.0	169.0	353.0	25	25.0	5.5
October	Alfalfa (mature):													
	Sixth cutting (same as first cutting)					109.0	80.0							
	Winter pasture:													
	Irrigating	2		Shovels	2.0 acres	0 0	13.0							
	Plowing	1	3	14-in. sulky plow	0.2 acres	189.0	63.0							
	Harrowing	1	3	6-ft. spring-tooth harrow	0.5 acres	75.0	25.0							
	Seeding	2	2	Wagon and broadcaster	3.0 acres	9.0	9.0							
	Harrowing	1	2	10-ft. spike-tooth harrow	1.5 acres	18.0	9.0							
	Total					400 0	199 0	27.0	188 0	427 0	387 0	22	26 5	7 5
	Totals for year					1,424.0	1,137.0	320.0	2,200.0	1,744.0	3,327.0	245	251 0	36 0

years the acreage consists of mature alfalfa, 25 acres, and annual pasture crops, 12½ acres. Thereafter each 3-year cycle of the rotation is a repetition of the first so far as acreages of crops are concerned.

Farming Practices.—The methods employed in preparing for planting, and producing crops and in handling the dairy herd are those customarily followed on farms of this type in the Turlock area. The calendar of operations (tables 40 and 41) indicates the details of these operations.

Yields and Carrying Capacity.—The yields of crops upon which the labor requirements, as shown in the calendars of operations, are based and upon which the carrying capacity of this farm was computed are as follows:

Alfalfa (season of seeding)	2 tons per acre
Alfalfa (mature)	5 tons per acre
Winter pasture	Equivalent to 3 tons per acre
Summer pasture	Equivalent to 4 tons per acre

The per-acre yield of crops is the controlling factor in determining the numbers of livestock which can be supported on a given acreage. This cropping program, with yields as given above after reserving the equivalent of 18 tons of hay a year for the workstock, will supply roughage feeds for 20 cows, 1 bull, and 4 heifers raised for replacement purposes. Concentrates for these cattle are purchased either from neighboring farmers or local feed concerns.

THE CALENDAR OF OPERATIONS

The calendar of operations for this 40-acre dairy farm is presented in two parts: (1) For the first year of the rotation when the crops are alfalfa (new seeding), 12½ acres; alfalfa (mature), 12½ acres; winter and summer irrigated pasture (double-cropped), 12½ acres; and (2) for the second and third years when the crops consist of alfalfa (mature), 25 acres; winter and summer irrigated pasture (double-cropped), 12½ acres. The calendars thus drawn up indicate the tasks to be performed and labor required for planting, caring for, and harvesting the various crops and caring for the dairy herd. Chore work, such as the feeding and care of the workstock and other routine work are not included in the calculations.

Producing field crops and conducting a dairy under the plan followed on this farm means that the operator is kept busy for practically all of his available time. This amounts to an average daily expenditure of 6 hours in connection with the dairy plus another 6 hours in the field

during times of planting, growing, and harvesting crops. A 20-cow dairy and its accompanying program of feed production is thus capable of keeping the operator fully employed. The figures are shown in table 42.

TABLE 42

MAN AND HORSE LABOR REQUIREMENTS ON A 40-ACRE DAIRY FARM

Order of Rotation*	Man labor					Horse labor				
	Total required	By operator	Operator's efficiency†	Hired	Per cent hired	Total required	By farm-owned horses	Efficiency of farm-owned horses‡	Hired	Per cent hired
	hours	*hours*	*per cent*	*hours*	*per cent*	*hours*	*hours*	*per cent*	*hours*	*per cent*
First year	3,530	3,204	87.5	330	9.3	2,274	2,249	34.0	25	1.1
Second year¶	3,337	3,012	82.3	325	9.7	1,744	1,744	26.4	0	0.0

* Acreage of crops for each year of rotation given on pages 95 and 96.

† Based on 6 hours a day for 365 days (caring for dairy cows) and 6 hours a day for 245 days for field work, a total of 3,660 hours.

‡ Based on a total of 6,615 hours a year.

¶ Third year of rotation same as the second year.

The three horses maintained as a part of the equipment are not particularly well utilized from the standpoint of efficiency. Their average use results in an efficiency of only about 30 per cent and hence the daily cost of using horses tends to be rather high.

Extra labor must be hired to help out for those operations requiring the services of more than one man and during times when the work piles up so that the operator cannot handle it himself. The labor is needed for only a few days at a time, usually for 6 days or less in any 1 month. During the 24 months shown on the calendar, extra labor is needed for 18 of these months and ranges in amount from ½ to 8 days a month. The hiring of men on a daily basis is the only feasible plan.

It is again pointed out that efficient use of the operator's time (and of that of horses) is not necessarily a final criterion of the desirability of a farm plan. The final test is the amount of net farm income obtainable. This is set forth in the tabulations which follow.

FINANCIAL RESULTS

Compilations of data reflecting the investment items required to organize and equip this farm, production of marketable products, factors involved in cost of operation and maintenance and the calculation of annual and average net income for the 3-year cycle typical of the rotation, have been made to test the financial results of operating this farm under the plan described in the preceding pages.

Investment Items.—The items which constitute the total investment in this farm when fully equipped and operating are listed in detail below:

Land: 40 acres; leveled, checked, ditched, and cross fenced; supplied with water from the Turlock Irrigation District

Buildings and structures:
- Dwelling, septic tank, and garage. These items, though necessary, are not considered as a part of the farm investment.
- Horse barn, with storage for hay and implements
- Water tank, tower, pump, motor, piping and fittings for lifting and distributing water to house and barn
- Corral for horses
- Milking barn for 20 cows
- Shed for bull and calves
- Milk house
- Corrals for bull and calves
- 4 canal headgates
- 76 outlet boxes from ditches to checks

Motive power:
- 3 horses
- Automobile (primarily for personal use and not included as a part of the farm business)

Implements and machinery:
- (This list is the same as that given under the 40-acre field-crops farm, with the exceptions that the bean and corn planter, bean row splitter, bean cutter, and cultivators are not needed; a manure spreader is added.)

Horse equipment:
- 1½ sets of work harness
- 3 horse collars
- 3 halters and tie chains
- Curry comb, brush, barn broom, manure fork, hoof rasp, clippers, etc.

Dairy equipment:
- 2 milk buckets
- Milk stool
- 12 milk cans
- Hand milk truck
- Milk cooler
- Barn broom
- Manure fork
- Wheelbarrow
- 50 feet of ¾-inch hose
- Set of veterinary instruments
- Lasso
- Nose ring and leader for bull
- Curry comb
- Brush
- Square-pointed shovel

Tools, hand implements, and minor equipment:
4 metal tappoons (for use in irrigating)
Set of carpenter's tools
Carpenter's vise
Small set of mechanic's tools
Pipe vise, stock, dies, and cutter
Pick, shovels, hoes, pitchforks, crowbar, axe, grindstone, etc.
Post-hole digger and chain blocks
Sickle sharpener, rubber boots, wheelbarrow, ladders, baled-hay hooks, oil cans

Statement of Production.—The production of crops on this farm is designed to supply feed for the dairy stock. Since this farm is stocked to the limit of its carrying capacity for the yields and crops as given, there will be no crops available for sale. The total annual production and the amounts of milk fat, and the number of surplus calves and culled cows available for sale are shown in table 43. All manure produced is retained for use on the crop land of the farm.

TABLE 43

TOTAL PRODUCTION AND AMOUNTS OF MILK FAT, CALVES, AND CULLED COWS AVAILABLE FOR SALE ON A 40-ACRE DAIRY FARM*

	Milk fat	Calves	Cows
	pounds		
Production per cow	312	.....	.....
Total annual production	6,240	19	.....
Farm use	40†	4‡	.....
Discarded	.....	3¶	3
Available for sale	6,200	12	3

* All manure retained for use on farm crops.
† For rearing calves.
‡ Reserved for herd replacement; 3 cows to be discarded annually.
¶ 3 calves discarded at birth, as not worth rearing.

Financial Statements.—The unit factors involved in production and maintenance of this 40-acre dairy farm and financial statements, with selected selling prices and costs, for each of the 2 years typical of the rotation are presented in table 44.

The average annual net farm income from this dairy farm is $920.48 when the production per herd, selling prices of milk calves and cows, and expenses are as given in table 44. This is considerably less than the minimum amount of net farm income considered necessary by most farm operators to maintain a satisfactory standard of living. The findings indicate a definite need for an improvement in the situation.

TABLE 44

INCOME AND EXPENSES OF A 40-ACRE DAIRY FARM

Annual gross income	First year	Second year*
Whole milk for manufacturing purposes, containing 6,200 pounds of milk fat at $0.40	$2,480.00	$2,480.00
Calves, 5 at $5.00; 7 at $2.00	39.00	39.00
Discarded cows, 3 at $45.00	135.00	135.00
Total	$2,654.00	$2,654.00

Annual expenses	First year	Second year*
Hired labor at $2.25 per 9-hour day†	$ 83.25	$ 81.00
Seed:		
Alfalfa, 250 pounds at $0.20	50.00	.....
Barley, 750 pounds at 1¼ cents	9.38	9.38
Vetch, 250 pounds at $0.08	20.00	20.00
Sudan grass, 188 pounds at 7½ cents	14.10	14.10
Dairy supplies:		
Salt, 575 pounds at $0.80 per 100 pounds	4.60	4.60
Washing powder, 50 pounds at $0.15	7.50	7.50
Medicines	5.00	5.00
Feeds:		
Dried skim milk for calves, 1,000 pounds at $0.06	60.00	60.00
Concentrates for calves, 2,000 pounds at 1.6 cents	32.00	32.00
Concentrates for milking herd, 12 tons at $26.00	312.00	312.00
Contract work:		
Hauling milk, 6,200 pounds of milk fat in whole milk at 3½ cents	217.00	217.00
Testing production of cows at $1.50 per cow per year	30.00	30.00
Renting extra horses at $1.00 a day	3.00	0.0
Irrigation water at $3.67 an acre	146.80	146.80
Electricity, annual pro rata charge	9.10	9.10
Upkeep and repairs of equipment:		
Buildings, 5.0 per cent of $1,629.00 (Dwelling, garage, and septic tank not included)	81.45	81.45
Irrigation structures, 2.4 per cent of $370.00	8.88	8.88
Implements and machinery, 3.2 per cent of $943.00	30.18	30.18
Harness, collars, halters, and tie chains for horses, 1.0 per cent of $94.00	0.94	0.94
Dairy equipment, 0.4 per cent of $122.00	0.49	0.49
Small tools, barn, and minor equipment, 1.2 per cent of $180.00	2.16	2.16
Domestic pumping plant. 0.5 per cent of $548.00	2.74	2.74
Veterinary expense	30.00	30.00
Taxes:		
Land in alfalfa	80.75	80.75
Land in annual crops, farmstead, lanes, and ditches	31.15	31.15
Buildings (based on average value)	11.25	11.25
Work animals (based on average value)	4.56	4.56
Dairy cows and bull	32.30	32.30
Implements and machinery (based on average value)	7.14	7.14
Dairy equipment	0.74	0.74
Hay	1.72	1.72

(*Concluded on p. 108*)

* Income and expenses of the third year are the same as the second year.

† First year, 37 days; second year, 36 days.

TABLE 44—(*Concluded*)

Annual expenses—(*Concluded*)

	First year	Second year*
Depreciation of equipment:		
Buildings, 5.0 per cent of $1,629.00. (Dwelling, garage, and septic tank not included)	81.45	81.45
Irrigation structures, 11.8 per cent of $370.00	43.66	43.66
Implements and machinery, 12.2 per cent of $943.00	115.05	115.05
Work animals, 10.0 per cent of $375.00	37.50	37.50
Bull, 16.0 per cent of $100.00	16.00	16.00
Harness, collars, halters, and tie chains for horses, 16.6 per cent of $94.00	15.60	15.60
Dairy equipment, 26.2 per cent of $122.00	31.96	31.96
Small tools, barn and minor equipment, 12.2 per cent of $180.00	21.96	21.96
Domestic pumping plant, 7.4 per cent of $548.00	40.55	40.55
Insurance:		
Horse barn, 1.3 per cent of $225.00	2.92	2.92
Cow barn, 1.3 per cent of $170.00	2.21	2.21
Hay in horse barn, 1.3 per cent on hay valued at $9.50 a ton for 6 months	2.14	2.14
Hay in stack, 2.5 per cent on hay valued at $9.50 a ton for 6 months‡	20.78	29.69
Employers' liability, 2.9 per cent of payroll	2.41	2.35
Total	$1,764.45	$1,718.05

Net income

	First year	Second year*	Average 3 years¶
Annual gross income	$2,654.00	$2,654.00	$2,654.00
Annual expenses	1,764.45	1,718.05	1,733.52
Annual net income	$ 889.55	$ 935.95	$ 920.48

* Income and expenses of the third year are the same as the second year.

‡ First year, 87.5 tons; second year, 125.0 tons.

¶ Average annual gross income, expenses, and net income figured for the 3-year period typical of the rotation.

POSSIBLE CHANGES IN FINANCIAL RESULTS

The calendar of operations shows that the operator of this farm is so busily engaged with the work of raising feed crops and caring for the dairy stock that he cannot undertake more work, such as adding more enterprises or increasing the size of the business, without relying on hired help to perform the additional work. Improvement must, therefore, be sought in other directions. Possibilities worth considering are: (1) increased production per cow, (2) a better price for the products, (3) improved crop yields, which increases the carrying capacity of the farm, (4) sale of manure, and (5) a reduction in the outlays required to maintain and protect the farm capital invested in equipment. These possibilities will be considered in some detail.

Effect of Increased Production per Cow.—An annual production of 312 pounds of milk fat per cow for a 300-day milking period does not

constitute a particularly high yield. The experience of Stanislaus County dairymen indicates that a yield of 380 pounds of milk fat is not out of the realm of realization. To secure the added production would require the feeding of more concentrates. Yet allowing for the cost of the additional concentrates the average annual net farm income on the basis of this higher production would be substantially increased as follows (averaged for 3 years):

Gross income (prices remaining as given in table 44)	$3,198.00
Expenditures as given in table 44 (after allowing for increase in hauling charge, $47.60, and 6 tons additional concentrates at $26.00 a ton)	1,937.12
Net farm income	$1,260.18

An increase in production of milk fat of about 22 per cent provides for an increase in the net farm income of 37 per cent.

By testing the herd and culling out the poorer producing cows, by careful purchase of proven producers, and by proper handling of the dairy herd it is possible to increase production over the figures used in table 44, even without the added expense incident to the feeding of concentrates. Attention to increased production warrants all the effort that the operator can expend to bring this about and thus increase the earnings of the farm.

Effect of Changes in Prices of Dairy Products.—Some improvement may be possible in the price received from the sale of calves, though its effect is likely to be of only limited importance since the number for sale is small.

An increase in the prices paid for manufacturing milk would obviously be a material aid in increasing the net income. If instead of 40 cents a pound the price should rise to 50 cents, production and expenses remaining the same as given in table 44, then the net farm income would amount to $1,540.48, an increase of $620.00.

For a herd averaging 380 pounds of milk fat a cow annually, the increase would be $756.00 and the net farm income would be increased to $2,016.88.

Possibly the price of 40 cents obtainable for milk fat is too optimistic. It is conceivable that prices may drop to lower levels. If so, the effect on net income for farms such as this would be decidedly serious. If prices decline to 30 cents, or perhaps to 20 cents a pound for milk fat, and costs remain as given in table 44, the effect on net income would be as follows:

Net income, milk fat at 40 cents (as shown in table 44)	$920.48
Net income, milk fat at 30 cents	610.48
Net income, milk fat at 20 cents	463.60

Effect of Increased Crop Yields.—In the basic plan governing the handling of this farm, calculations have been made on the basis of usual yields.

The question now arises: What would be the financial result if good yields were obtainable instead of merely usual yields, that is, if yields of new alfalfa were 3½ tons instead of 2, mature alfalfa, 8 tons instead of 5, and pasture crops produced enough to provide for the increased number of cows that could be carried because of the greater tonnage of alfalfa hay?

A test of this proposal, made by revising the production statement, calendar of operations, and financial statements of the original plan to provide for the increased production, results in the following:

Carrying Capacity: The increase in crop yields, amounting to 60 per cent, will permit an increase in the size of the herd from 20 cows to 32 cows. Six heifers would be raised instead of 4.

Additional Equipment: A larger barn is required, costing $545.00 instead of $340.00 and some increases in the minor equipment, such as milk buckets, cans, etc.

Labor Requirements: The labor requirements, taken from the calendar of operations revised in accordance with the changes which this plan entails, are summarized in table 45.

TABLE 45

MAN AND HORSE LABOR REQUIREMENTS ON A 40-ACRE DAIRY FARM WITH A 32-COW HERD

Year of rotation	Man labor					Horse labor				
	Total required	By operator	Operator's efficiency*	Hired	Per cent hired	Total required	By farm-owned horses	Efficiency†	Hired	Per cent hired
	hours	*hours*	*per cent*	*hours*	*per cent*	*hours*	*hours*	*per cent*	*hours*	*per cent*
First	4,177	3,638	94.7	539	12.9	2,410	2,385	36.1	25	1.1
Second‡	4,085	3,347	87.2	738	18.1	1,908	1,908	28.8	0	0.0

* Based on 3,840 hours annually.

† Based on a total of 6,615 horse hours a year.

‡ Third year is same as second.

Financial Statements: The financial statement for the 40-acre dairy farm, revised in accordance with the changes required by increasing from a 20 to a 32-cow herd, is shown in detail in table 46 for each of the 2 typical years of the rotation.

An increase in net farm income from $920.48 (table 44) to $1,973.71, as a result of increasing crop yields, is evidence of the necessity of making each acre produce to its full capacity—or, when a change is possible,

of getting lands capable of producing good yields rather than farming lands which will produce no better than usual yields of crops.

TABLE 46

Income and Expenses of a 40-Acre Dairy Farm with a 32-Cow Herd

Annual gross income

	First year	Second year*
Sale of 9,924 pounds of milk fat at $0.40	$3,969.60	$3,969.60
Sale of calves, 8 at $5.00, 12 at $2.00	64.00	64.00
Discarded cows, 5 at $45.00	225.00	225.00
Total	$4,258.60	$4,258.60

Annual expenses

	First year	Second year*
Hired labor* at $2.25 per 9-hour day	$ 135.00	$ 184.50
Materials:		
Seed (same as table 44)	93.48	43.48
Dairy supplies	27.36	27.36
Concentrates: for calves, 1.5 tons at $32.00	48.00	48.00
Concentrates for milking herd, 19.2 tons at $26.00	499.20	499.20
Dried skim milk for calves, 1,500 pounds at $0.06	90.00	90.00
Contract work:		
Hauling milk, 9,924 pounds of milk fat at 3½ cents	347.34	347.34
Testing cows at $1.50 each a year	48.00	48.00
Irrigation water	146.80	146.80
Electricity, annual pro rata charge	14.50	14.50
Upkeep and repairs of equipment (same as table 44, less cow barn)	109.84	109.84
Cow barn, 5 per cent of $545.00	27.25	27.25
Veterinary expense	40.00	40.00
Taxes:		
As given in table 44	169.61	169.61
On additional cows (12)	18.24	18.24
Depreciation of equipment (as given in table 44, except cow barn)	386.73	386.73
Of cow barn	27.25	27.25
Insurance:		
Horse barn (same as table 44)	2.92	2.92
Cow barn, 1.3 per cent of $272.50	3.54	3.54
Hay in horse barn (same as table 44)	2.22	2.22
Hay in stack† (same as table 44)	34.20	47.50
Employers' liability, 2.9 per cent of payroll	3.92	5.35
Total	$2,275.40	$2,289.63

Net farm income

	First year	Second year*	Average 3 years
Gross income	$4,258.60	$4,258.60	$4,258.60
Expenditures	2,275.40	2,289.63	2,284.89
Net farm income	$1,983.20	$1,968.97	$1,973.71

* First year, 60 man days; second year, 82 man days.

† First year, 144 tons; second year, 200 tons.

Sale of Manure.—Good farm management dictates that all manure produced should be kept for use on the home farm rather than for this valuable source of plant foods and organic matter to be sold. In times of stress, however, a sale may be justified. If so, then there would be a total of about 50 tons of manure which could be sold at a price of about $1.50 a ton. This would increase the net farm income by $75.00.

Reduction in Overhead Expenses.—This farm requires reserving annually sums of $126.84 for upkeep and repairs and $403.73 for depreciation (in order to replace items that wear out or become useless). This is a total of $530.57. This suggests that all possible attention should be paid to prolonging the life of the equipment in order to reduce this figure to as low a level as possible. Better protection, prompt repairing, and more care in the use of implements, and the prolonging of the productive life of the cows will pay in dollars and cents and add directly to the net farm income.

USE OF OUTLOOK REPORTS

Once the basic plan of crop rotation for any given farm has been determined, selection of the crops to be grown during any specific year is a matter of vital importance if the greatest possible net income is to be obtained. Market prices of most annual crops are subject to rather wide and sometimes violent fluctuations. An inquiry should therefore be made of each of the alternative enterprises as to the probable market prices which are likely to prevail at the time the crop is to be harvested. As part of this inquiry, use may well be made of the federal *Agricultural Outlook* published annually by the United States Department of Agriculture, Bureau of Agricultural Economics, and the *Agricultural Outlook for California* presented annually by the Agricultural Extension Service, College of Agriculture, University of California. These reports present a summary of the current available facts bearing upon the future economic conditions of important farm products, the former for important producing sections and the entire country in relation to domestic and world markets, the latter for the state of California in relation to national and world markets. In some instances the outlook as presented in the federal and state reports must be modified to meet local conditions. For crops not mentioned in the Outlook reports or where special local conditions prevail, current and timely data pertaining to market demand, stocks on hand in the case of nonperishable commodities, and probable plantings in this and competing areas, should be as-

sembled, analyzed, and deductions drawn as to the crop which will be likely to present the most favorable conditions at the time of harvest.

With properly planned crop rotations, the large number of field and truck crops adapted to this area makes possible a flexibility of cropping programs admirably suited to the judicious use of outlook information in planning the year's production program.

For example, the cropping program of the 40-acre field-crops farm centering around the production of alfalfa as the principal legume for soil improvement, and including in addition, the annual crops of barley for hay, Blackeye beans, and grain sorghum, should not be considered as final but merely suggestive of a readily workable plan of organization built upon a crop rotation designed to maintain soil fertility.

Several alternative enterprises for each of the annual crops of barley for hay, Blackeye beans, and grain sorghums are available and may be readily substituted in the rotation whenever the price outlook justifies their consideration. In place of barley for hay, other winter cereals (e.g. oats or wheat) may be produced for hay, grain, or winter pasture. A late crop of grain sorghum or one of the several types of melons may be substituted for the Blackeye beans, and where soil and water conditions permit, either cantaloupes, melons, or sweet potatoes may be substituted, in whole or in part, for the grain sorghums during the third year of the rotation. Similarly, replacement of the present enterprises by alternatives may be made in the cropping programs of the truck-crops farm and the dairy farm as presented. The proposed plan should be tested in accordance with the procedure demonstrated in testing the advisability of substituting sweet potatoes for cantaloupes in the rotation on the truck farm, under the conditions as given.

CONCLUSIONS

The field investigations in the Turlock area and resulting studies of farm organizations and possible alternative plans, were undertaken in order to place in the hands of interested farmers and farm leaders a comprehensive method for testing existing plans of farm organization and proposed alternative plans.

Reorganization of many farms for the purpose of increasing their earning power is both desirable and practical. Such reorganization is especially necessary in times of low prices and their consequent effect upon earning power. Though involving considerable work, the determination of what plan is best suited to a given farm under stated or existing conditions is entirely feasible. Considering the farm in its en-

tirety as the producing unit, the first step consists in a careful determination of the present earning power. The next step consists in testing possible alternatives. Extensive use is made of the calendar of operations as a basis for calculating present earning power and for testing proposed changes in organization, for determining the kind and costs of additional equipment that is needed to carry out the various alternatives, and in the preparation of farm budgets.

The evidence is indicative of the influence of six major factors affecting the earning power of farms, viz., sizes of farms, types and proportions of various enterprises, yields, prices received for farm products, costs of operating and maintaining farms, and operators' abilities. Some farms are doubtless too small in size to provide a satisfactory net income unless the conditions governing the selection of the farm and its accompanying enterprises, and the handling of the farm reaches a high degree of efficiency. Some growers can profit by accumulating more knowledge and applying this knowledge in selecting suitable enterprises and in the handling of their crops and livestock. The choice of enterprises is important, and changes in the cropping plans of some farms will warrant attention. More attention to crop rotations and to building up the crop-producing power of the land in other ways appears to be in order. High yields are essential if large net incomes are to be obtained. Although the grower has some control over prices received for his product, through production on a more wholesale scale, by improving quality, by exercise of better salesmanship, or by joining in some cooperative movement, yet his influence upon prices will be, at best, relatively small.

The costs of the various goods and services used in production are determined largely by influences outside the jurisdiction of the operator. It is essential, nevertheless, that operators exercise due caution and care in making only expenditures in kind and amount required in administering the farm plan, in order to insure the production of commodities at lowest possible cost.

In its final analysis the question of increasing the earning power of any farm becomes largely a personal and individual matter. The means must be sought by each individual for himself. The tests of those means can, however, be reduced to a financial basis for study by following the procedures given at length throughout this publication. To present information concerning the nature and manner of making these tests was the goal set by the authors in compiling this publication.

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Many growers, shippers, officers of the Turlock Irrigation District, and others of the Turlock area willingly cooperated and contributed a great deal of the necessary basic data.

Assistance in compiling and analyzing the various data in the office was rendered by Paul Nystrom, Gus Israel, and W. C. Hansen.

APPENDIX A

SIZES OF FARMS IN THE TURLOCK AREA

Data from files of the Turlock Irrigation District indicate that the area under study contains 3,390 farm holdings. The farms range in size from less than 5 to over 1,280 acres. Of the total number, 73.5 per cent, however, are from 11 to 40 acres in size. The grouping of all farms by specified sizes is given in table 47.

TABLE 47

Size and Number of Farms in the Turlock Area

Size of farms, in acres	Number in group	Per cent of total in group
1–5	91	2.7
6–10	382	11.3
11–20	1,378	40.6
21–40	1,115	32.9
41–60	119	3.5
61–80	146	4.3
81–160	104	3.1
161–320	31	0.9
321–640	16	0.5
641-1,280	8	0.2
Total	3,390	100 0

These figures, while informative, do not necessarily show the acreages actually farmed by individuals in the area, since it is a prevalent practice to rent or lease holdings from others. This is particularly true in connection with the smaller size groups.

APPENDIX B

YIELDS OF CROPS AND LIVESTOCK PRODUCTS IN THE TURLOCK AREA

Crop yields of the Turlock area were obtained both from estimates of growers and their written records. For purposes of comparison, yields are grouped into three classes as follows:

Best yields: yields normally obtained over a period of years by 5 to 6 growers out of 100.

Good yields: yields normally obtained over a period of years by 10 to 12 growers out of 100.

Usual yields: yields obtained over a period of years by 40 to 50 growers out of 100.

No attempt is made to offer *average* yield figures because they are of little or no significance in organizing or reorganizing farms.

Table 48 gives the findings calculated on a per-acre basis for the principal commodities produced in the area.

In some localities of the area the presence of weeds tends to reduce yields. The most troublesome are Bermuda grass, water grass, bamboo, thistles, wild sunflowers, tumbleweeds, wild morning-glory, and pigweeds. Likewise, the prevailing practice of planting the same land year after year to the same crop tends toward a lowering of yields. Good yields are associated with the use of a regular and suitable system of crop rotation. On some soils use of green-manure crops is needed to insure continued good yields.

Either good or excellent yields, according to the figures given in table 48, are obtainable only on suitable soil properly handled.

TABLE 48

YIELDS OF MARKETABLE PRODUCTS IN THE TURLOCK AREA

Product	Crop yield per acre		
	Best	Good	Usual
Field crops:			
Alfalfa	10 tons	8 tons	5 tons
Beans:			
Blackeye (first crop)	25 sacks*	18 sacks*	12 sacks*
Blackeye (second crop)	16 sacks*	12 sacks*	9 sacks*
Baby Lima	15 sacks†	12 sacks†	9 sacks†
Grains:			
Barley	3,500 lbs.	2,500 lbs.	1,500 lbs.
Oats	2,500 lbs.	1,500 lbs.	1,000 lbs.
Wheat	3,000 lbs.	2,000 lbs.	1,000 lbs.
Grain hay	4 tons	3 tons	2 tons
Grain sorghums (first crop)	3,500 lbs.	2,500 lbs.	1,800 lbs.
Grain sorghums (second crop)	2,500 lbs.	1,800 lbs.	1,200 lbs.
Fruit crops (green basis):			
Apricots	10 tons	6 tons	4 tons
Grapes:			
Juice	10 tons	8 tons	6 tons
Table	12 tons	8 tons	5 tons
Peaches:			
Cling	15 tons	12 tons	8 tons
Freestone	18 tons	14 tons	9 tons
Fruit (dried basis):			
Apricots	4,000 lbs.	3,000 lbs.	2,000 lbs.
Peaches	7,500 lbs.	6,000 lbs.	4,000 lbs.
Raisins	6,000 lbs.	4,500 lbs.	2,500 lbs.
Nuts:			
Almonds	1,200 lbs.	800 lbs.	400 lbs.
Truck crops:			
Melons			
Cantaloupes	400 crates‡	250 crates‡	150 crates‡
Casaba	15 tons	10 tons	7 tons
Honey Dew	12 tons	9 tons	6 tons
Persian	12 tons	8 tons	6 tons
Watermelon	25 tons	18 tons	10 tons
Spinach	8 tons	6 tons	4 tons
Sweet potatoes	250 crates¶	150 crates¶	100 crates¶
Livestock products:			
Milk fat per cow	340 lbs.	300 lbs.	260 lbs.
Eggs per hen	15 doz.	12.5 doz.	10 doz.

* Sacks, 90 pounds net. † Sacks, 100 pounds net.
‡ Standard cantaloupe crate (12 x 12 x 22⅛ inches inside dimensions). ¶ Crates 75 pounds net.

APPENDIX C

SELLING PRICES OF FARM PRODUCTS IN THE TURLOCK AREA

Data were collected in the Turlock area to determine prices received by growers during the 9-year period from 1923–1931 inclusive. The figures are based on material gathered from producers, buyers, shippers, farmers' cooperative marketing associations, and from market quotations applicable to the area (table 49).

TABLE 49

APPROXIMATE AVERAGE PRICES OF FARM PRODUCTS FROM TURLOCK AREA, DELIVERED AT SHIPPING POINTS, 1923–1931

Crop	Unit	1923	1924	1925	1926	1927	1928	1929	1930	1931
Field crops:										
Alfalfa hay (baled)	ton	$14.50	$19.50	$13.50	$13.75	$15.00	$15.00	$19.50	$13 00	$10 00
Beans:										
Blackeye	cwt.	4.50	7.75	5.50	4.50	4.00	6.70	6.50	3.50	2.75
Baby Lima	cwt.	8.60	12 00	10.00	5.20	5.60	8.75	10.00	4.25	3.75
Grain:										
Barley	cwt.	1.30	2.20	1.45	1.10	1.90	1.65	1.40	0.90	0.95
Oats	cwt.	1.65	2.15	1.40	1.20	1.85	1.70	1.60	1.15	1.00
Wheat	cwt.	1.70	2.45	2.50	2.10	1.90	1.90	1.85	1.35	1.10
Grain hay (baled)	ton	12.00	20.00	13.00	10.00	11.00	13.50	14.50	11.00	9 00
Grain sorghum	cwt.	1.70	2.10	1.70	1.50	2.00	1.85	1.90	1.25	1.00
Fruit crops (green basis):										
Apricots (canning)	ton	30.00	50.00	60.00	70 00	65.00	50.00	75.00	40 00	25.00
Grapes:										
Juice:										
Black	ton	70 00	80.00	60 00	50 00	40.00	20 00	35 00	20 00	19 00
White	ton	.....	.....	20.00	.....	15.00	11.00	17.50	11 00	15 00
Table	ton	.....	.....	35.00	20.00	15.00	17.50	25.00	16 00	20.00
Peaches:										
Clingstone (canning)	ton	30 00	45 00	35.00	40.00	22.50	20.00	80 00	20 00	14 50
Freestone	ton	25.00	25.00	32.50	35.00	35.00	35.00	45.00	25 00	20 00
Fruit crops (dried basis):										
Apricots	cwt.	9 00	13.50	17.00	19.00	14.00	14.50	15 50	10 50	7 00
Peaches	cwt.	7.00	7.00	10.50	10.50	8 00	7 50	13 00	4 50	5 50
Raisins (seedless)	cwt.	2.50	3.00	3.60	3.50	3.00	2.00	3 00	2 90	3 50
Nuts:										
Almonds	cwt.	11.00	14.50	20.00	15.50	16.00	17.50	24 50	10 00	8 00
Truck crops:										
Cantaloupes	crate*	2.25	1.35	1.10	1.20	1 35	1 10	1 25	1 00	0 90
Melons:										
Casaba	ton	.....	.....	.....	8.00	10.00	10.00	10.00	15.00	10.00
Honey Dew	ton	.....	.....	30.00	11.00	25.00	14.00	20.00	20 00	20 00
Persian	ton	.....	.....	20 00	8.00	15.00	25 00	25 00	15 00	15 00
Watermelons	ton	.....	.....	30 00	6 00	10 00	12 00	14 00	15 00	10 00
Sweet potatoes	cwt.	3.00	4 50	3 00	2 00	2 50	2 00	2 00	1 50	1 50
Livestock products:										
Milk fat in cream	lbs.	0.52	0.45	0.53	0.48	0.49	0.50	0.49	0 38	0.28
Milk fat in whole milk	lbs.	0.62	0.52	0.61	0.59	0.62	0.60	0.61	0.49	0 35
Eggs—Large extra	doz.	0.35	0.33	0.37	0.33	0 29	0.30	0.32	0.26	0.20
Medium extra	doz.	.....	.....	.....	.....	0 24	0 25	0 28	0 21	0 15
Small extra	doz.	.....	.....	.....	.....	0 18	0 18	0 19	0 14	0 10
Poultry:										
Leghorn hens (large)	lbs.	0 17	0 17	0 20	0 20	0 18	0 18	0 22	0 18	0 15
Leghorn broilers	lbs.	$0 30	$0 32	$0 29	$0 28	$0 27	$0 30	$0 26	$0 25	$0 21

* Standard cantaloupe crate (12x12x22⅛ inches inside dimensions).

APPENDIX D

COSTS OF ITEMS OF FARM EXPENSE IN THE TURLOCK AREA

During the course of the field investigations data on cost of contract operations, equipment, fertilizers, insurance, seeds, and supplies to growers in the Turlock area were compiled for use in testing plans of farm organization. The data presented in tables 50 to 56 are representative of usual costs prevailing during the period 1928–1930 for the items listed, and were used throughout this publication in testing the various plans of farm organization or reorganization.

Costs of Selected Expenditures.—Costs of selected contract operations, feeds, insurance, supplies, and farm wages as used throughout this publication are presented in table 50.

TABLE 50

Costs of Selected Expenditures in the Turlock Area

General contract rates	
Plowing with tractor	$ 3.50 per acre
Disk harrowing with tractor	$ 1.50 per acre
Cultivating with tractor (disk or spring-tooth harrow)	$ 1.50 per acre
Hauling	
General rates 1–3 miles	$ 1.00 per ton
3–5 miles	$ 1.50 per ton
Over 5 miles (first 5 miles at $1.50) each additional mile	$ 0.10 per ton
To Bay Region	$12.50 per ton
To Bay Region, Los Angeles lugs*	$ 0.20 each
2-ton truck with driver	$ 2.50 per hour
Specific rates	
Milk fat:	
In cream	$ 1.00 per cwt.
In whole milk	$ 3.50 per cwt.
Cantaloupes:	
Minimum	$ 0.03 per crate
Up to 10 miles	$ 0.01 per crate mile
Casabas, Honey Dews, watermelons, etc., in bulk:	
1–4 miles	$ 1.00 per ton
4–8 miles	$ 1.50–2.00 per ton
Empty boxes (back to ranch):	
Los Angeles lugs	$ 0.50 per hundred
Picking lugs	$ 1.00 per hundred
Grain:	
1–10 miles	$ 0.80–1.25 per ton

Specific crop contracts

Alfalfa:	
Baling from stack	$ 2.50–3.00 per ton
Apricots:	
Picking, for drying	$ 5.00 per ton
Cutting, per 50-pound lug box	$ 0.10–0.15 per box
Beans:	
Planting	$ 1.50 per acre
Threshing	$ 0.45 per sack
Cleaning	$ 2.00 per ton
Fumigating	$ 1.50 per ton
Cantaloupes:	
Picking per standard crate	$12.50 per hundred
Packing per standard crate	$ 5.00–6.00 per hundred
Picking, sorting, and packing (owner hauls from field	$ 0.20–0.22 per crate
Picking, hauling, sorting, and packing	$ 0.25 per crate
Grain:	
Threshing (without pitchers)	$ 0.15 per sack
Grapes, juice:	
Picking and packing in Los Angeles lug	$ 0.03–0.04 per lug
Grapes, table:	
Picking and packing in Los Angeles lug	$ 0.04–0.05 per lug
Picking and packing in Los Angeles lug (juice)	$ 3.50 per ton
Peaches:	
Picking for cannery	$ 3.00 per ton
Cutting, per 40-pound lug box	$ 0.05 per box
Sorghums, grain:	
Threshing (including sack sewing), per 130-pound sack	$12.50 per hundred
Threshing (including sack sewing)	$ 1.60 per ton
Sweet potatoes:	
Sorting and packing	$ 0.22 per crate
Testing cows, per cow per year	$ 1.50 per cow

Cost of dairy supplies

Stock salt	$ 0.80 per 100 pounds
Washing powder	$ 0.15 per pound

Farm wages

Pruners and spraymen	$ 2.70 per 9-hour day
Teamsters, hay pitchers, irrigators, etc.	$ 2.25 per 9-hour day

Cost of fertilizers

Lime	$ 8.00 per ton
Stable manure	$ 1.00 per ton
Sulfur	$57.00 per ton

Cost of insurance

Fire:	
Barns and contents (other than livestock and feed, annual average for 3-year policy)	1.3 per cent of value of coverage

Outbuildings and contents	1.0 per cent of value of coverage
Grain, in field	3.0 per cent of value of coverage
Hay, in stacks (85.0 per cent recoverable in case of fire)	5.0 per cent of value of coverage
Hay, in barns (85.0 per cent recoverable in case of fire)	2.5 per cent of value of coverage
Fire and theft: trucks	1.6 per cent of value of coverage
Employers' liability	2.9 per cent of payroll
Cost of market containers	
Cantaloupe crates	$ 0.17 each
Grape lugs (#2)	$ 0.10 each
Sacks	
Bean	$ 0.09 each
Grain	$ 0.09 each
Sweet potato crates	$ 0.21 each
Twine (sack)	$ 0.75 per pound
Cost of spraying and dusting materials	
Bluestone	$ 0.08 per pound
Lime-sulfur (concentrated)	$ 0.18 per gallon
Quicklime	$ 0.01 per pound
Nicodust	$ 0.20 per pound
Sulfur	$ 0.04 per pound
Cost of stock feeds	
Mixed feeds:	
For calves	$32.00 per ton
For cows	$26.00 per ton
Poultry mash	$38.00 per ton
Poultry scratch	$30.00 per ton
Powdered skim milk	$ 0.06 per pound
Cost of tractor, truck, and automobile supplies	
Gasoline	$ 0.15 per gallon
Lubricating grease	$ 0.25 per pound
Lubricating oil	$ 0.64 per gallon

* Standard Los Angeles lug is 5¾x13½x16¼ inches (inside dimensions) and contains 24 to 26 pounds net weight of deciduous fruits or grapes.

Costs of Seeds: The range and usual market price of seeds, as reported by seed dealers in the Turlock area, are presented in table 51.

Cost of Irrigation Water.—Irrigation water for all lands within the area studied is supplied by the Turlock Irrigation District. An annual per-acre charge is levied by the District regardless of the amount of water used. The method of computing the irrigation tax is based on an assessed valuation of the lands (without improvements) evaluated according to their relative productivity, at an established rate of taxa-

TABLE 51

COSTS OF SEEDS IN THE TURLOCK AREA

Crop	Range in price per cwt.	Usual price per cwt.
Alfalfa	$16.00- 22.00	$20.00
Barley	1.00- 2.50	1.25
Beans, Blackeye	3.00- 8.00	6.00
Beans, Baby Lima	7.00- 11.00	10.00
Beans, Small Horse	10.00- 14.00	12.00
Cantaloupes	100.00-200.00	150.00
Casaba melons	100.00-150.00	150.00
Egyptian corn	2.50- 5.00	4.00
Honey Dew melons	100.00-150.00	150.00
Melilotus alba	12.00- 19.00	15.00
Melilotus indica	5.00- 10.00	6.00
Milo	4.00- 7.00	5.00
Oats	2.00- 2.50	2.25
Persian melons	300.00-500.00	300.00
Rye	1.50- 2.50	2.00
Spinach	16.00- 20.00	18.00
Sudan grass	6.00- 12.00	7.50
Sweet potatoes	2.50- 3.50	3.00
Watermelons	75.00-200.00	150.00
Wheat	1.50- 3.25	2.00
Vetch, common	6.00- 9.00	6.00
Vetch, purple	9.00- 15.00	12.00
Vetch, winter	$10.00- 16.00	$13.00

tion. From 1923 to 1928 the tax rate per $100.00 of assessed valuation was $4.50. In 1929 the rate was reduced to $4.25. The 1930 rate was likewise $4.25. For the purposes of this study the tax rate of $4.50 per $100.00 of assessed valuation is used throughout.

Within the area studied the assessed valuation of the lands mostly range from $50.00 to $150.00 an acre, which, at a tax rate of $4.50 per

TABLE 52

COST PER ACRE OF IRRIGATION WATER IN THE TURLOCK AREA

Crop	Principal range in assessed valuation	Usual assessed valuation	Usual annual cost* of water
Field crops:			
Alfalfa	$65–110	$85	$3.82
Beans	75–110	90	4.05
Grain sorghums	60- 90	75	3.37
Irrigated pasture	60- 90	75	3.37
Orchards	90–150	125	5.62
Vineyards	75–115	100	4.50
Truck crops	$90–118	$100	$4.50

* Based on rate of $4.50 per $100.00 assessed valuation.

Source of data:
Office of Turlock Irrigation District, compilation and computations by authors.

$100.00 of assessed valuation, indicated a possible range in the annual charge for irrigation water of $2.25 to $6.75 an acre.

The principal range and usual assessed valuation of lands for each type of crop and the usual cost of irrigation water per year are given in table 52.

Cost of County Tax.—The valuation of lands assessed for county taxes range from $20.00 to $150.00 an acre on a bare-land basis. Improvements are assessed in accordance with a standard schedule of valuations in which permanent plantings are listed as follows:

Alfalfa	$ 20.00 an acre
Mature deciduous orchards	$ 60.00 an acre
Mature vineyards	
Table or raisin grapes	$ 50.00 an acre
Juice grapes	$100.00 an acre

The total assessed valuation of lands supporting plantings is made up of the assessed valuation of the improvements added to the valuation of the bare lands.

For the fiscal year 1929–30, the tax rate per $100.00 assessed valuation within the area studied ranged from $3.05 to $5.30 with a general average of $3.66. This tax rate included the county base rate (outside incorporated cities), school tax, and improvement-district taxes. In computing the costs of producing farm crops used in this study, a standard tax rate of $3.80 per $100.00 of assessed valuation was used

TABLE 53

ASSESSED VALUATION AND COUNTY TAXES PER ACRE IN THE TURLOCK AREA

Crop	Principal range in assessed valuation of bare land	Usual assessed valuation of bare land	Assessed valuation of permanent plantings	Total usual assessed valuation	Annual tax* per acre
Field crops:					
Alfalfa	$35–100	$65	$20	$85	$3.23
Beans	50–100	90	....	90	3.42
Grain sorghums	35–100	55	....	55	2.09
Irrigated pasture	35–100	55	....	55	2.09
Trees and vines:					
Orchard (full bearing)	80–140	100	60	160	6.08
Vineyard (full bearing):					
Juice	60–120	100	100	200	7.60
Table and raisin	60–120	100	50	150	5.70
Truck crops:					
Cantaloupes	90–125	100	....	100	3.80
Melons	50–125	100	....	100	3.80
Sweet potatoes	$90–125	$100	....	$100	$3.80

* Based on tax rate of $3.80 per $100.00 assessed valuation.

Source of data:
Compiled by authors from data on file in Offices of County Assessors and Tax Collectors, Merced and Stanislaus counties.

(in order to take in years of higher tax rates prior to the fiscal year 1929–30) with assessed valuations of lands for each crop as given in table 53.

Purchase Cost, Depreciation, and Cost of Repairs for Selected Types of Farm Structures, Equipment, and Livestock.—Tables 54 to 56 provide data concerning (a) purchase cost, (b) average annual rate of depreciation, and (c) average annual cost of repairs for items commonly required in carrying on farms devoted to field, truck, fruit, and livestock enterprises. The purchase costs are for good quality, serviceable equipment, bought for cash, and as of January, 1932.

TABLE 54

FIRST COST, DEPRECIATION, AND ANNUAL CHARGE FOR REPAIRS OF FARM BUILDINGS AND STRUCTURES

Item	Construction cost	Average annual rate of depreciation	Average annual charge for repairs
	dollars	*per cent**	*per cent**
Farm buildings and structures:			
Barns:			
Horse barn and implement shed (24 ft. x 50 ft., 24 ft. to ridge, 8 ft. to eaves)	550.00	5.0	3.0
Milking barn:			
10-cow capacity	200.00	5.0	3.0
20-cow capacity	340.00	5.0	3.0
32-cow capacity	545.00	5.0	3.0
Poultry house, 500 fowl capacity (18 ft. x 70 ft. and 10 ft. x 18 ft. feed room, complete with piping)	672.00	5.0	3.0
Domestic water supply (installed):			
Well, 8 in.—40 ft.	150.00	5.0	.....†
Motor, 1 H.P.	115.00	12.5	3.0
Tower	183.00	4.0	.....†
Tank, 2,000 gallons	100.00	7.0	.....†
Piping:			
Field crops, fruit, and truck farms	21.00	5.0	1.0
Dairy farm	62.00	5.0	1.0
Fencing (per rod):			
Cow corral (boards)	2.57	5.0	3.0
Horse corral (boards)	2.50	5.0	3.0
Poultry yard	2 .48	5.0	2.0
Implement shed (18 ft. x 56 ft., earth floor)	110.00	5.0	3.0
Milk house (8 ft. x 10 ft., concrete floor)	70.00	5.0	3.0
Packing shed, cantaloupe (18 ft. x 18 ft.)	32.00	5.0	3.0
Tractor shed (14 ft. x 24 ft., concrete floor)	202.00	5.0	3.0
Water troughs, each	25.00	5.0	5.0
Irrigation structures:			
Headgates, each	14.00	7.0	1.0
Lath furrow pipes, each	0.05	50.0	.....†
Outlet boxes, each	4.00	12.5	3.0
Tappoons, each	2.50	20.0	.....†

* Per cent of construction cost. † Amounts are inconsequential.

TABLE 55

PURCHASE PRICE, ANNUAL RATE OF DEPRECIATION, AND CHARGE FOR REPAIRS OF FARM EQUIPMENT

Item	Purchase price	verage annual rate of depreciation	Average annual charge for repairs
Implements and machines:	*dollars*	*per cent*	*dollars*
Broadcaster, hand	6.50	16.7	0.20
Bean row splitter	8.00	10.0	0.50
Bean cutter	45.00	10.0	0.80
Cultivators:			
1-row, walking	10.00	10.0	1.00
2-row, riding	76.00	10.0	2.50
Eveners, per set	5.00	10.0	.....*
Harrows:			
4-ft. single disk	63.00	16.7	2.50
5-ft. double disk	128.00	14.0	5.00
Spike-tooth, per section	13.00	10.0	0.50
Spring-tooth, per section	17.00	10.0	1.00
Hay stacker	85.00	10.0	2.50
Lister, 12-in.	26.00	10.0	1.00
Manure spreader	200.00	8.0	6.00
Melon planting sled	25.00	5.0	0 20
Mower, 5-ft.	110.00	10.0	6.00
Plank drag	10.00	10.0	.....*
Planter, 2-row corn or bean	75.00	8.3	2.00
Plows:			
Gang, 2—12-in.	132.00	10.0	4.00
Sweet potato	22.00	10.0	1.00
Sulky, 14-in.	104.00	12.5	3.00
Walking, 8-in.	18.00	10.0	0.50
Walking, 10-in.	22.00	10.0	0.75
Walking, 12-in.	28.00	10.0	1.00
Rake, 10-ft.	69.00	10.0	2.00
Ridger, disk	135.00	7.0	1.00
Scrapers:			
Bucket	22.00	7.0	0.25
Fresno	37.00	10.0	0.20
Sweet potato transplanter	120.00	7.0	5.00
Wagon, 1½-ton	90.00	8.3	1.50
Wagon, 2½-ton	160.00	8.3	2.50
Horse and barn equipment:			
Baled-hay hooks, 2	0.70	10.0	.....*
Broom, barn	1.50	100.0	.....*
Brush, horse	0.75	33.3	.....*
Collars, each	7.50	16.7	.....*
Curry comb	0.35	50.0	.....*
Halters, each	2.50	16.7	0.25
Harness:			
Double-chain work	45.00	20.0	2.00
Double-leather work	65.00	20.0	2.00
Harness awl	1.00	10.0	.....*
Harness punch	1.25	10.0	.....*
Hoof clippers	1.75	10.0	.....*
Hoof rasp, 14-in.	0 60	25.0	.....*
Mane and tail shears	0.85	10.0	.....*
Manure fork	2.50	20.0	.....*
Tie chains, each	1.25	33 3	.....*
Wagon jack	2.50	10.0	.....*
Wagon wrench	1.75	5.0	.....*

(Continued on p. 126)

* Amounts are inconsequential.

TABLE 55—(*Continued*)

Item	Purchase price	Average annual rate of depreciation	Average annual charge for repairs
	dollars	*per cent*	*dollars*
Dairy equipment:			
Broom, barn	1.50	100.0	.....*
Brush, cow	0.75	33.3	.....*
Bull nose ring	0.50	10.0	.....*
Curry comb	0.50	50.0	.....*
Fly sprayer	1.50	33 3	.....*
Hose, ¾-in., per foot	0 12	33 3	.....*
Kicking chains	0.75	20.0	.....*
Lasso	3.50	20.0	.....*
Lead chain	0.25	20.0	.....*
Manure fork	2.50	20.0	.....*
Manure shovel, square point	1 50	10 0	0.10
Milk buckets, 14-qt., each	2.00	50 0	.....*
Milk cans, 10-gal.	5.00	33.3	0.50
Milk cooler	10.00	10 0	.....*
Milk stool	home made	.....	.....
Milk truck, hand	12.50	10.0	.....*
Veterinary instruments (trocar scapel, milk-fever outfit, syringe, teat slitter)	12.25	10.0	.....*
Orchard equipment:			
Brush burner	125.00	10.0	1.50
Buckets, picking, each	0.25	33.3	.....*
Duster, sulfur	15.00	12.5	0.50
Ladders, per foot	0.40	12.5	.....*
Props and hooks, each	0.12	20.0	.....*
Pruning saws, each	1.75	16.7	.....*
Pruning shears, each:			
Hand	3.25	20.0	.....*
Long-handled	4.00	20.0	0.25
Tree	2.75	20.0	0.25
Seeder, hand broadcaster	6.50	16.7	0.20
Spray machine	300.00	10.0	10.00
Spray-mixing barrels, each	1.50	20.0	.....*
Poultry equipment:			
Broom	1.50	100.0	.....*
Catching net	0.75	33 3	.....*
Egg buckets, each	0 35	50 0	.....*
Egg cases, 30-doz.	2.00	50.0	.....*
Egg scales	1.25	10.0	.....*
Feed buckets, each	0.50	50 0	.....*
Feed troughs, each	3.00	20.0	.....*
Scoop shovels, each	1.50	10.0	.....*
Scraper (for dropping boards)	1.00	10.0	.....*
Sprayer, hand	17.50	10.0	0.50
Wheelbarrow	8.50	10.0	.....*
Hand tools and implements:			
Axe, felling	1.50	10.0	0.10
Axe, splitting	1.50	10.0	0.10
Crowbar, 16-lb.	2.75	4.0	.....*
Hoes, 6-in., 2	2 50	20.0	.....*
Jab planter	1.75	10.0	.....*
Mattock, 16-in.	1.50	10.0	.....*
Pick, 8-lb.	1.50	10.0	.....*
Pitchforks, 2	3.50	12.5	0.25

* Amounts are inconsequential.

TABLE 55—(*Continued*)

Item	Purchase price	Average annual rate of depreciation	Average annual charge for repairs
Hand tools and implements—(*continued*)	*dollars*	*per cent*	*dollars*
Shovels:			
Round point, long handle, 2	3.00	10.0	0.20
Square point, long handle	1.50	10.0	0.10
Sickle	1.25	10.0	.....*
Snath, scythe, and brush hook	4.25	10.0	.....*
Miscellaneous:			
Bucket, galvanized	0.50	33.3	.....*
Funnel	0.50	20.0	.....*
Glass cutter	0.35	50 0	.....*
Gopher traps	0.25	33.3	.....*
Grindstone	12.00	10.0	.....*
Hay knife	2.00	10 0	.....*
Oil can, ½-pt	0.25	20.0	.....*
Platform scales, portable	35.00	5.0	.....*
Putty knife	0.25	5.0	.....*
Rubber boots	6.00	33.3	.....*
Step ladder, 8-ft	3 25	10.0	.....*
Wheelbarrow	6.50	12.5	.....*
Whitewash brush	2.00	25.0	.....*
Carpenter tools:			
Brace, rachet, and 6 bits, assorted	4.00	10.0	.....*
Chalk line, 40-ft	0.15	33.3	.....*
Chisels, set of 6, assorted	4 50	10.0	.....*
Draw knife, 12-in	1.50	10.0	.....*
Expansive bit	1.50	10.0	.....*
Files, set of 6, assorted	1.50	50.0	.....*
Hammer, claw	1.25	10.0	0.05
Half hatchet	1.25	10.0	.....*
Hatchet	1.50	10 0	.....*
Oil stove	1.50	20.0	.....*
Plane, 15-in. jack	4.25	5.0	.....*
Plane, 10-in. smoothing	3.75	5.0	.....*
Rule, 3-ft	0.75	33.3	.....*
Saw, 26-in. cross-cut	2.75	7.0	0.50
Saw, 26-in. rip	2.75	7.0	0.50
Spirit level	3.50	10.0	.....*
Screw drivers, set of 3, assorted	1.65	10.0	.....*
Square, 12-in. meter	0.85	5.0	.....*
Square, 24-in. steel	2.50	5.0	.....*
Steel tape, 100-ft	2.50	10.0	.....*
Wrecking bars, 30-in., 2	1.00	5.00	.....*
Mechanical tools:			
Bearing scrapers, set	1.25	10.0	.....*
Cold chisel, 7-in	1.00	10.0	.....*
Hammers, ball peen, 2 (1 and 2 pounds)	1.75	7.0	.....*
Pliers, 2 pair, 6 and 8-in	2.00	10.0	.....*
Screw jacks, 2	4.00	5.0	.....*
Tin snips, 12-in	2.00	10 0	.....*
Valve-grinding tools	2.00	10.0	.....*
Valve lifters	0.75	10.0	.....*
Vise	5.50	5.0	.....*
Wrenches:			
Crescent, set of 3, 6, 8, and 10-in	3.00	10.0	.....*
End, set of 6	3.00	10 0	.....*
Knife handle (monkey)	1.50	10.0	.....*
Socket, set of 6	1.75	10.0	.....*

(*Concluded on p. 128*)

* Amounts are inconsequential.

TABLE 55—(*Concluded*)

Item	Purchase price	Average annual rate of depreciation	Average annual charge for repairs
Pipe fitting tools:	*dollars*	*per cent*	*dollars*
Hack saw, 12-in.	1.60	10.0	.....*
Oil can	0.50	20.0	.....*
Pipe cutter	3.25	10.0	0.10
Pipe stock and dies	9.50	10.0	0.50
Pipe vise	3.00	5.0	.....*
Stillson wrenches, 18-in., 2	6.00	7.0	.....*
Blacksmith tools:			
Anvil, 100-lb.	15.00	3.0	.....*
Cooling tub	1.00	20.0	.....*
Forge	25.00	5.0	.....*
Hammer	1.25	10.0	.....*
Hardy	1.00	20.0	.....*
Sledges, 16-lb., 2	4.50	5.0	.....*
Tongs, 20-in.	2.00	5.0	.....*
V Wedges, iron, 10-in., 2	1.50	5.0	.....*
Fencing tools:			
Chain blocks, ½-ton capacity	12.00	10.0	.....*
Post-hole digger	2.75	10.0	0.15
Staple puller	0.75	10.0	.....*
(For hammer, shovel, and crowbar see other lists)			
Concrete and brick laying tools:			
Brick hammer	1.15	10.0	.....*
Concrete mixer	45.00	7.0	.....*
Trowel, 10-in.	2.00	10.0	.....*
Trowel, pointing	0.50	10.0	.....*
(For shovels see other lists)			

* Amounts are inconsequential.

TABLE 56

PURCHASE PRICE, ANNUAL RATE OF DEPRECIATION, AND MORTALITY OF FARM LIVESTOCK

Item	Purchase price	Average annual rate of depreciation and mortality
Livestock (per head):	*dollars*	*per cent*
Bulls	100–250	16.0
Dairy cows	40–75	20.0
Horses, work stock	100–150	10.0
Laying hens	1.25	66.0
Pullets	0.75	.....

The figures are suggestive. Proper care and expert use will tend to prolong the life and lessen the outlay for repairs. The reverse will shorten the life and add to the repair bills. Some items have practically an indefinite life (such as crowbars, platform scales, wrenches, etc.) yet a life has been assigned in order that the original purchase price may ultimately be absorbed.

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BERKELEY, CALIFORNIA

28

The Economic Significance of Tree Size in Western Sierra Lumbering

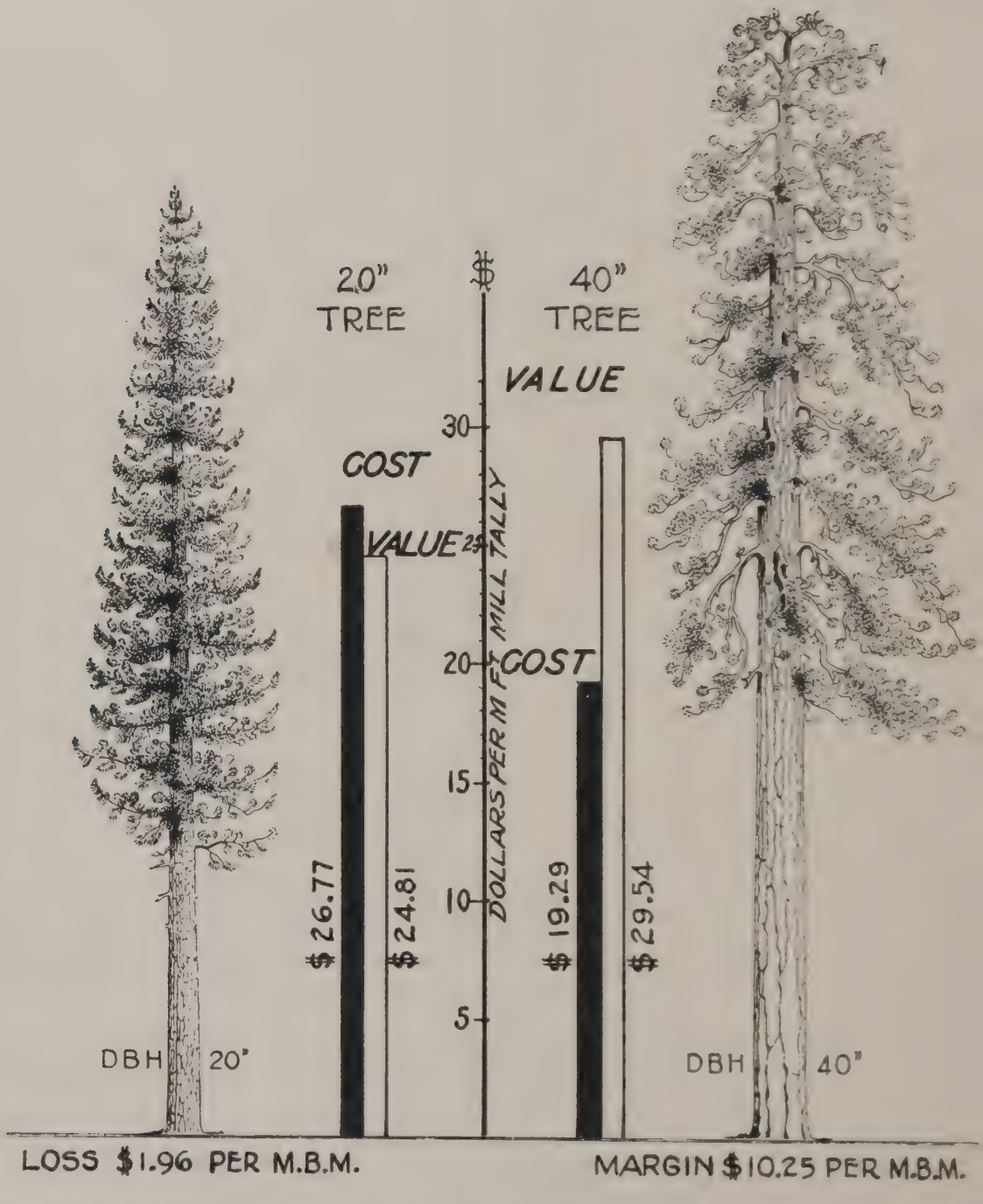
M. R. BRUNDAGE, M. E. KRUEGER, and DUNCAN DUNNING

Results of an investigation conducted by the California Forest Experiment Station of the Forest Service, United States Department of Agriculture, in co-operation with the California Agricultural Experiment Station.

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Relation of tree size to costs and values in two ponderosa pines. One thousan board feet of lumber cut from 40-inch trees yielded a margin of $10.25, but th cost of producing that volume of lumber from 20-inch trees was $1.96 greater tha its value. The costs given in the graph do not include fixed acre charges, o stumpage.

The Economic Significance of Tree Size in Western Sierra Lumbering[1]

M. R. BRUNDAGE,[2] M. E. KRUEGER,[3] AND DUNCAN DUNNING[4]

INTRODUCTION

Size as an Index of Value.—In the lemon groves of southern California, the picking crews are provided with circular wire gauges having an inside diameter slightly smaller than the diameter of the smallest-sized fruit which will bring a fair profit on the market. The lemon crop is not harvested completely in one picking, or in two pickings, for the lemon tree is continuously sending forth new buds and developing new fruits. Each time the picking crew make the rounds they find lemons in all stages of development. Their instructions are to pick all obviously mature fruit, regardless of size, but in the selction of the green thrifty specimens, they are to pick nothing which will slip through the ring gauge.

It may seem a rather far-fetched analogy, at first glance, to compare lemons with pine trees, for the operation of lumbering is immensely more complex than picking and packing lemons; nevertheless lemon selection illustrates admirably the meaning and the application of economic diameter limit. Not only that, but the removal of overmature and diseased lemons, regardless of size, in order fully to utilize the productive capacity of the tree for growth of sound, thrifty fruit, and to minimize sources of infection, carries a lesson also in desirable forestry practice.

True, the small fruit left for subsequent picking will be large enough for the market in a few weeks or a few months, whereas the small forest tree will not be commercially ripe for many years. But is it good business for a forest owner to cut "any tree that will make a 2 x 4" just because he does not expect to get back over the ground again within his own lifetime? Even though the lemon-grove owner expected to sell his grove in August he would not order his picking crew, as they made

[1] Received for publication September 13, 1932.

[2] Associate Forester, Office of Forest Products, California Forest Experiment Station. The California Forest Experiment Station is maintained at Berkeley, California, by the Forest Service, United States Department of Agriculture, in cooperation with the University of California.

[3] Associate Professor of Forestry and Associate Forester in the Agricultural Experiment Station.

[4] Silviculturist, California Forest Experiment Station.

their last rounds in July, to disregard their ring gauges and bring in everything on the trees, for the very good reason that one box of lemons costing $4.00 and bringing a return of $5.00 yields more net profit than the same box plus another box costing $4.50 and bringing a return of only $4.00.

In the California pine region, the virgin stands contain trees in all stages of development, from the tender seedling to the massive, grizzled veteran whose age may be counted by centuries. In the old days of the bull team, only the choicest trees were cut. As the population grew, lumber prices went up, new machinery was invented, railroad spurs meandered up the draws and along the ridges and there was an ever increasing tendency to cut lower and lower into the small-diameter range. At the present time it is rather common practice on privately owned timberlands in the western Sierra pine region to cut all pine trees down to and including those having butt diameters of only 12 to 16 inches. Is anything gained by harvesting these small sizes, or do they, perhaps, yield an inferior product and entail such high handling costs that their inclusion in the mill-run output has the effect of actually lowering the average annual net profits to the owner or operator? Is it not pertinent to inquire whether the economic principles which apply to the selection of lemons in the California citrus belt may not apply also to the selection of trees in California's commercial pine region?

The Function of Logging and Milling Studies.—It is impossible to answer the foregoing questions from even the most painstaking analysis of the standard operating-cost and selling-value records of the average lumber company. In spite of their elaborate detail with respect to operation subdivisions, the accounts cannot be dissected to show the costs of converting any particular class of raw material into lumber. Though the trees cut and logged may have run all the way from 14 inches to 80 inches in diameter, the figures show only the averages for the entire monthly or seasonal output. Even the cost of one species as compared with another is irretrievably hidden in the averages.

This does not imply that no single item of the total expense can be properly allocated from the usual company records, for there are a few expenditures, such as the annual taxes on the manufacturing plant, which are always converted to an M.B.M.[5] basis by dividing total annual expenditure by total annual production, irrespective of species or the size and class of log from which the lumber is cut; and there are other expenditures—the construction of railroad spurs, truck roads, and woods camps, for example—which may readily be reduced to an M.B.M.

[5] The abbreviation "M.B.M." is used throughout this bulletin for "thousand feet board measure."

basis simply by dividing the total cost for a given area by the total volume in M.B.M. cut from that area. Differences in species of timber or in sizes of logs again do not enter into the calculations, although the cost on an M.B.M. basis varies with the net volume logged to a particular series of spurs or from a particular logging camp.

Incidentally, it is probably the effort to spread this expense, i.e., the initial cost for making a timber tract accessible, over the greatest possible footage of lumber, which has been chiefly responsible for the prevailing practice of cutting small trees on private lands, particularly the pines, down to minimum d.b.h.[6] limits of 12 and 14 inches. The fixed acre[7] operating costs, however, while they appear large for a section of land, or an entire season's logging, ordinarily constitute but 10 to 15 per cent or less of the total conversion charges. The only explanation appears to be that all operators can readily see the favorable effect of greater acre yield on this cost item, while the adverse effect of heavy cutting on a much larger share of the total operating expenses has escaped notice because it is entirely concealed in the annual-statement averages.

But the amount spent by the operator for felling, limbing, bucking, yarding, loading, transporting logs to the mill, unloading, sawing, pulling lumber from the green chain, stacking, seasoning, and subsequent handling will be very different for a tree containing 3,000 board feet than for a tree containing only 300 board feet. This is so obvious that no supporting data are necessary to establish the general fact that these costs do vary with tree size. But to determine just *how much* one tree costs as compared with another requires a cost-keeping system showing almost the same detail for logs and trees of any given species and size class as is shown in the operator's annual statement for the woods-run production. Knowing the cost for, and the volume of, a particular size of tree, it is of course a very simple matter to convert to cost per M.B.M.

Selling values must be segregated in the same way, naturally, if margins for different tree sizes are to be derived. The operator's record shows only the mill-run production of various species, grades, and sizes of lumber. The special record must account for the grades and sizes of material cut from each log and tree.

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[6] The abbreviation "d.b.h." means "diameter breast high" and refers to tree diameter measured outside the bark about 4½ feet above the ground line. Wherever tree sizes are given in this bulletin, d.b.h. is implied.

[7] With efficient planning, there should ordinarily be a decrease in railroad building and an increase in average yarding distance with a decrease in volume per acre cut. In this report, however, fixed acre costs are assumed to be the same, irrespective of the percentage of the stand removed. More comments on this phase will be found under, "Cutting to Different Minimum-Tree-Diameter Limits," page 53.

A logging and milling study is essentially a cost-accounting and value-finding analysis carried to a much greater degree of refinement than the regular bookkeeping system. Such a study may include supplementary records not ordinarily kept by the private operator—logging damage surveys, for example, or special insect and disease research, or growth studies on the woods plots after logging—but its primary aim is to determine the comparative marginal values of the widely varying sizes and classes of raw material found in the commercial forest. The units of study are the individual log and the individual tree.

Some Results of Other Logging and Milling Studies.—Several reports of coordinated logging and milling studies in the eastern half of the United States have been published during the past decade. Stands and conditions studied were radically different from those in the west, however, so no specific results will be cited here. In general, all of the investigations showed that operators were actually paying more for the cutting and handling of many of the smaller trees than they were receiving for the lumber produced from such trees.

In California, Berry[(1)][8] found from head-saw time studies made in band-mills during 1914 and 1915 that the time required to cut 1 M.B.M. of lumber from 8-inch[9] and 9-inch logs was almost three times the average for 1 M.B.M. mill run. In a mill in the Plumas National Forest, the 1915 cost of sawing 8-inch logs was $3.68 per M.B.M.; 10-inch, $2.95; 20-inch, $1.73; 30-inch, $1.31; 37-inch, $1.23. This is equivalent to an increase of about 41 per cent in cost per M.B.M. with decrease in log diameter from 37 inches to 20 inches, and an increase of 70.5 per cent from 20 inches to 10 inches. Lumber from the 8-inch logs cost 2.99 times as much to saw as lumber from the 37-inch logs.

Sawing-time studies made by Show[(10)] a few years later gave a somewhat greater increase in cost with decrease in log diameter—$5.65 per M.B.M. for sawing 8-inch logs, $4.33 for 10-inch, $2.12 for 20-inch, $1.62 for 30-inch, and $1.50 for 40-inch. The lumber from 8-inch logs in this investigation, therefore, cost 3.77 times as much to saw as lumber from 40-inch. The same investigator also calculated comparative sawing costs per M.B.M. for the smaller diameters of trees. The results were: 12-inch trees, $5.65; 14-inch, $4.77; 16-inch, $4.00; 18-inch, $3.73; and 20-inch, $3.45 per M.B.M. This is an increase of 63.7 per cent in the cost of sawing with decrease in tree diameter from 20 inches to 12 inches. The sawing cost per M.B.M. for 20-inch trees was about twice as great as that for 40-inch trees.

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[8] Superscript numbers in parentheses refer to "Literature Cited," at end of this bulletin.

[9] All log-diameters given in this bulletin refer to the average diameter measured inside the bark at the smaller end of the log.

Concurrent records of lumber-grade production from logs of different sizes obtained by Berry[1] showed the rapid decline in percentage of uppers with decrease in log diameter. Applying these data by log grades and sizes to the woods run of logs from two different cutting systems on the same sample area, he found that the inclusion of small trees cut under private practice reduced the average percentage of uppers from 34.8 to 29.0 in the mill run of sugar pine (*Pinus lambertiana*), and from 40.7 to 37.2 in the mill run of ponderosa pine (*Pinus ponderosa*),[10] as compared with Forest Service cutting, which left practically all of the smaller, limby trees standing. Even with the low selling values of the 1914–1915 period, there was a difference of $1.14 per M.B.M. on sugar pine, and $0.48 per M.B.M. on ponderosa pine in favor of the selective-cutting practice.

Several other mill-production studies have been made by the Forest Service since that time in order that basic timber appraisal data shall conform with changes in cutting practices and grading rules. Price[9] in 1924 calculated the values for ponderosa-pine trees of different diameters in the eastern Lassen region by application of the grade-percentage figures from one of these later studies to stand tables showing the logs in each tree by log grade and diameter. Using 1921–1923 average selling prices, he obtained the following results for different sizes of trees:

D.b.h. in Inches	Value per M.B.M.
16	$24.80
24	25.80
30	29.20
40	34.90
50	$37.70

Starting then with the mill-run average value for all trees 12 inches d.b.h. and over, i.e., from clear cutting, the gains in value with successively lighter degrees of cutting were calculated:

Per Cent of Original Volume Cut in Trees 12 Inches d.b.h. and Over	Average Value per M.B.M. Mill Run
100.0	$32.86
93.8	33.28
86.1	33.73
75.5	34.21
63.0	$34.61

[10] The common name "ponderosa pine" used in this bulletin refers to the species formerly designated by the common name "western yellow pine."

Each decrease in volume removed was based on the leaving of all trees in progressively poorer thrift classes, not on diameter limits. The lightest cut of 63.0 per cent was all in class 5, defined as "mature and overmature" trees, largely in sizes over 32 inches d.b.h. The heaviest cut next above clear cutting, viz., 93.8 per cent, left only the class 1 trees. These were the trees of most rapid growth, with pointed tops, and numerous small limbs covering 75 per cent or more of the total length and ranging in size from 12 inches to 31 inches d.b.h. Classes 2, 3, and 4 were progressively larger and slower growing.

Felling, limbing, marking, and bucking studies by Bruce[4] showed that these four activities combined cost over three times as much per M.B.M. log scale for 18-inch trees as for 48-inch trees in 1922. The actual costs were $2.05 per M.B.M. for 18-inch trees, $1.07 for 30-inch, $0.78 for 40-inch, and $0.66 for 48-inch trees.

For donkey yarding, Bruce[5] found the cost was five to eight times as much per M.B.M. for 18-inch as for 48-inch trees.

Krueger[8] published, in 1929, the results of tractor-logging studies made on ten different areas in the pine region. With direct tractor skidding, 14-inch logs cost four to five times as much, and 20-inch logs about twice as much, per M.B.M., as 40-inch logs, to yard from stump to landing. In bunching for big-wheel yarding, 22 minutes were required, on the average, to spot 1 M.B.M. gross scale of 12-inch logs, while with 40-inch logs, the time was only 3 minutes per M.B.M. On a log-volume basis, logs scaling 100 board feet cost $1.94 per M.B.M. for bunching as compared with $0.30 per M.B.M. for logs scaling 1,200 board feet. Yarding with caterpillar-tread hydraulic arches cost four to five times as much per M.B.M. for 600 board-foot as for 3,000 board-foot loads. Loads of 1,000 board feet cost a little less than three times as much per M.B.M. as 3,000 board-foot loads.

Hughes,[7] in a fairlead arch wheel study in 1930, correlated yarding costs per M.B.M. with volumes of the average logs in the various loads timed. The cost per M.B.M. for 100 board-foot average logs was $4.11, 500 board-foot logs, $1.02, and 1,600 board-foot logs, $0.64. These figures show that the 100 board-foot size cost approximately four times as much per M.B.M. as the 500 board-foot size, and almost six and one-half times as much as the 1,600 board-foot size.

It will be noted that each of the California studies cited covered only partial phases of the operation of lumbering, i.e., none of them followed the log or the tree all the way from stump to dry-lumber-storage shed or shipping platform. Considered as a whole, however, they furnish substantial evidence that the lumber from the smaller trees in the Cali-

fornia pine region costs the operator considerably more than the lumber from larger trees or from the average tree and is worth considerably less in selling value. The only missing links in the chain of these published reports on California lumbering are the comparative transportation costs for small and large logs from woods-landing to sawmill and the comparative costs and depreciation for trees of different sizes after the lumber is pulled from the green chain.

Of interest to California operators, although not applicable to California stands and conditions, are the reports of coordinated logging and milling studies recently conducted by the Forest Service in central Oregon and in the Inland Empire. In the Oregon study,[6] the maximum average margin per M.B.M. between total costs and f.o.b. selling values came from cutting to a minimum tree-diameter limit of 24 inches, inclusive. This removed 73.7 per cent of the total volume in trees 10 inches d.b.h. and over. The stand was practically pure ponderosa pine and the topography was fairly level. A Lidgerwood skidder was used for yarding.

In the Inland Empire,[2] the high value of western-white-pine (*Pinus monticola*) No. 1 and 2 Common made it possible to utilize very small trees of this species without sustaining an actual loss[11] although the lumber from 12-inch trees cost nearly 30 per cent more to produce than the lumber from 38-inch trees. The maximum margin per M.B.M. in a sample stand of western white pine was obtained, however, by cutting to a minimum d.b.h. limit of 20 inches. The smallest trees of other species whose values were not below production costs were: ponderosa pine, 16 inches; western larch (*Larix occidentalis*), 18 inches; Douglas fir (*Pseudotsuga taxifolia*), 16 inches; and white fir (*Abies grandis*), 18 inches. Minimum cutting limits for maximum margin per M.B.M. were appreciably above these zero-margin sizes.

The most recent studies in territory adjacent to California are those in the Douglas fir region of Washington and Oregon. A report by Brandstrom[3] in 1931, gave comparative woods costs for different sizes of logs and trees and for different methods of yarding. A few of the results, selected at random, are as follows: in felling, maximum production in M.B.M. per man hour was obtained from 48-inch trees; 16-inch trees cost three times as much per M.B.M. for felling and bucking as 36-inch trees; tractor skidding with fairlead arch wheels was the cheapest of seven yarding methods observed; in fairlead arch yarding, the costs for 1,000 feet distance were $1.64 per M.B.M. for logs scaling

[11] The selling values and average operating costs used were for the period 1921–1925, inclusive. All data cited are for sound trees only.

200 board feet, $0.63 for logs scaling 1,000 board feet, and $0.34 for logs scaling 4,000 board feet, which means that the 200-board-foot size cost nearly five times as much per M.B.M. to yard as the 4,000-board-foot size; car-loading costs were $3.85, $1.76, $0.38, $0.21, $0.13, and $0.10 per M.B.M. for logs scaling 50, 100, 500, 1,000, 2,000, and 3,000 board feet, respectively.

Stevens and Bruce[11] published, in 1931, an illustrative summary of partial results secured by them in various private lumbering studies for individual operators in different parts of the country. The purpose of the article was to present a bird's-eye view, so to speak, of the scope of selective cutting appraisals for unit operations and the better economic planning made possible thereby. An example from one investigation showed the degree of cutting during the first cycle which would give the greatest possible present worth to the property after discounting average annual realization per M.B.M. at 6 per cent interest. Clear cutting would yield $1.00 per M.B.M. for 20 years giving a present worth of slightly over $500,000, but a 50 per cent cut, i.e., leaving one-half of the original total volume in the small, low-grade trees, but not reducing the annual output of the mill, would yield a net realization of $5.50 per M.B.M. for about 10 years, giving a maximum present worth of $1,900,000. Still lighter cutting—about 25 per cent—would return a profit of $7.00 per M.B.M. but this would last for only 5 years, reducing the present worth to $1,400,000. In the authors' concluding paragraph, they state, "In reviewing some of the work that we have done we have found that the increase in the possible realizations per M.B.M. has ranged from 63 per cent to as high as 500 per cent. The corresponding increase in the present worth of the properties has been from 28 per cent to 232 per cent."

Scope and Purpose of This Bulletin.—This report, limited to a condensed account[12] of current operating economics as related to log and trees sizes, is based on the first completely coordinated logging and milling study to be undertaken by public forest-research agencies in the

[12] By "condensed account," it is meant that the detailed results from the numerous time studies, lumber-grade-production summaries, lumber-depreciation inspections, etc., have been omitted. Being the first study of its kind conducted in California for the information of the public and the lumber industry in general, publication of results has been divided into two distinct types of presentation: (1) a greatly abridged summary for those interested primarily in studying the end results without being distracted by the mass of intermediate technical minutiae upon which they are based, and (2) a compendium of the data from each separate phase of the study suitable for application in determining economic size limits and cutting systems elsewhere in the California west-slope region. This bulletin is the summary report only. The compendium of data for appraisers' use will be made available by the California Forest Experiment Station as soon as possible either in printed or mimeographed form.

California region. Entire trees were traced from the stump to the sawmill lumber-sorting table by a system of numbers placed on the ends of logs prior to yarding. Beyond the green chain, part of the lumber was later reinspected for seasoning degrade and remanufacturing changes by grade, thickness, and width.

Growth studies on the area following logging, special studies of decay and insect losses, and a logging-damage survey were also made a part of the general project. Growth observation will be continued indefinitely as a part of the regular Experiment Station series of permanent sample plots. Although the major objective of the investigation was the determination of comparative tree values in the virgin stand, provision was made in the working plan for study of all factors affecting management of the area from the forestry viewpoint as well as those factors affecting present operating margins only.

As is well known, there is a distinct difference between general conditions in the northeastern part of the California pine region, commonly referred to as the "east slope," and those in the forests bordering the Great Valley west of the Sierra divide, called the "west slope." Variations occur also between different operations in the same subregion. Among the most important variables influencing relative production costs or average values, or both, are (1) volume of stand per acre; (2) type, or mixture of species; (3) range of tree sizes present and the relative proportions of each size by volume; (4) percentage of defect; (5) site quality, or growing conditions; (6) topography; (7) type of logging and kind of equipment used; (8) surface conditions, such as the frequency of rock outcrops, which have an important bearing all along the line, from their effect on breakage in felling to their influence on spur and mainline railroad construction costs; (9) the length of haul between woods and mill; (10) capacity of sawmill and type of sawmill equipment; and (11) lumber-grade selling values f.o.b. mill.

With so many possibilities for variation in the factors governing the margin between expense and income it is evident that no simple rules can be laid down with blanket recommendations for application by all operators in a given lumbering region or subregion. As a matter of fact, a single operator will find it profitable to vary his style of cutting within different units of his own holdings. No claim is made, therefore, that the results of this study represent hard and fast lines of demarcation between the profitable and the unprofitable in all virgin stands of west-slope, Site-1 timber. Nevertheless, they do reflect general trends which are similar throughout the region, for the felling, yarding, sawing, and other partial phases studied by previous investigators show essentially

the same relations between cost and diameter as those resulting from the analysis of the various partial phases in this coordinated study.

The object of this report is primarily to show the cumulative effect of all variables combined as they worked out from the standpoint of operating economics under a particular set of conditions on a unified, complete operation. Summation of the variables is possible only when they are all reduced to the common denominator of dollars and cents. Such procedure has been followed, therefore, in this presentation of the study results. The technical background of *each* variable, if included in full, would be more apt to confuse than to help the reader in obtaining a clear perspective of this cumulative effect of *all* variables.

WOODS-STUDY AREA AND STAND

Description of Area.—The woods-study area, a little over ¼ mile in average width, measured up the slope from the railroad spur, and approximately ½ mile long, measured parallel with the spur, was located in the Stanislaus National Forest, on the North Fork of the Tuolumne River, in Tuolumne County, California. An area of 81 acres was mapped for topography and 73.7 acres was marked for cutting. As may be seen from its position on the outline map of California in figure 1, the area is approximately in the center of the west-slope pine region.

The elevation of the lowest point was 5,680 feet; the highest point was 6,000 feet. The horizontal distance between lowest and highest points was 1,980 feet. The average slope between above points was 16.2 per cent. Maximum slope for a distance of 100 feet was 50 per cent. There were no adverse grades against the tractor loads. Figure 2 is a topographic map of the woods-study area with contours drawn at 10-foot intervals.

The surface was generally smooth without loose rock but with a few fixed boulders or outcrops on the steeper slopes at about middle distance from the landings. The soil was deep and moderately loose.

Site quality was No. 1, i.e., the area was representative of the best growing conditions found in the west-slope pine region.

The Virgin Stand.—The original stand was sugar-pine—white-fir type, based on number of trees. Proportions in each species by volume were radically different from those by tree count, sugar pine (*Pinus lambertiana*) and ponderosa pine (*Pinus ponderosa*) combined constituting 54 per cent of the volume in only 29 per cent of the trees 12 inches d.b.h. and over, while white fir (*Abies concolor*) and incense cedar (*Libocedrus decurrens*), with 71 per cent of the trees, constituted only 46 per cent of the volume.



Fig. 1.—Location of Stanislaus woods-study area.

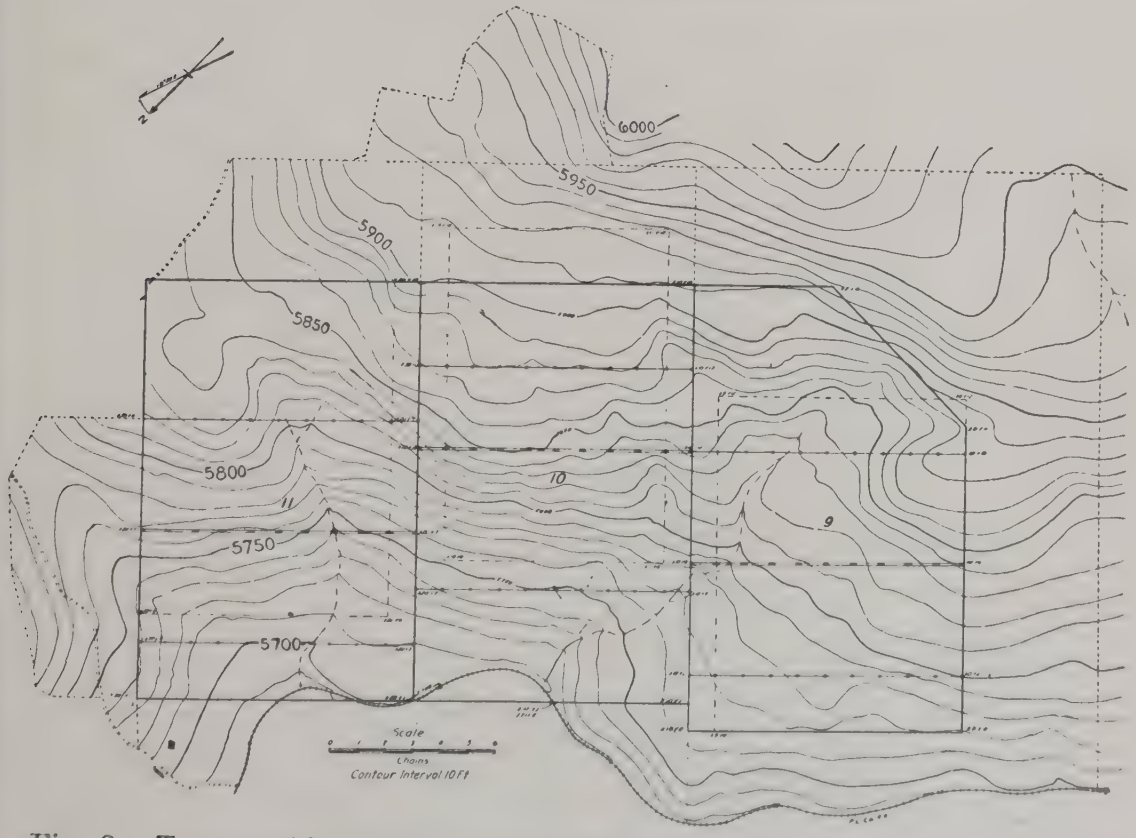


Fig. 2.—Topographic map of Stanislaus woods-study area. The subplots (in solid lines) will be observed periodically for data on growth as influenced by different cutting methods.

Table 1 summarizes the average number of trees and average gross volume per acre of each species in trees 12 inches d.b.h. and over. The volumes, and those in figure 3, are volume-table footages based on d.b.h. and tree-height measurements made prior to felling, and have not been reduced for estimated tree cull or breakage in logging.

TABLE 1

ORIGINAL STAND PER ACRE OF TREES 12 INCHES D.B.H. AND OVER ON THE STANISLAUS STUDY AREA

Species	Trees		Gross volume		Board feet in average tree
	Number	Per cent	Board feet	Per cent	
Sugar pine	8.63	20.61	20,374	34.37	2,361
Ponderosa pine	3.41	8.14	11,690	19.72	3,428
White fir	21.01	50.18	20,585	34.72	980
Incense cedar	8.82	21.07	6,635	11.19	752
Total	41.87	100.00	59,284	100.00	.....

Although sugar-pine and white-fir acre volumes were almost the same, there were nearly two and one-half times as many white-fir trees. Ponderosa pine was the largest in average size. The tallest tree was a ponderosa pine 206 feet in total height. The tree of largest diameter was an 80-inch sugar pine. Average heights for selected diameters are shown in table 2.

TABLE 2

MERCHANTABLE HEIGHTS OF STANDING TREES MEASURED TO 8 INCHES TOP DIAMETER IN TREES WITH NORMAL TIPS

D. b. h., in inches	Sugar pine	Ponderosa pine	White fir	Incense cedar
	Heights in 16-foot logs			
20	4.0	3.9	4.3	2.5
30	6.3	6.3	6.4	4.3
40	7.6	7.9	7.9	5.7
50	8.7	9.1	9.0	6.8
60	9.7	10.3	10.0	7.7
70	10.5	11.2	.....	.....
80	11.0	.....	.....	.....

The large size of the two pine species will be apparent from a study of figure 3, illustrating graphically the comparative total volumes of each species and the proportionate amounts of each by 6-inch d.b.h. groups.

The total volume of both pines was 32,064 feet B.M. an acre. Of this total, 13,272 feet B.M. of sugar pine and 6,620 feet B.M. of ponderosa pine, 19,892 feet B.M. all together, *was in trees 48 inches and over* in diameter breast high. This volume amounts to 62 per cent of the total volume for pines, or 33½ per cent of the total volume for all species.

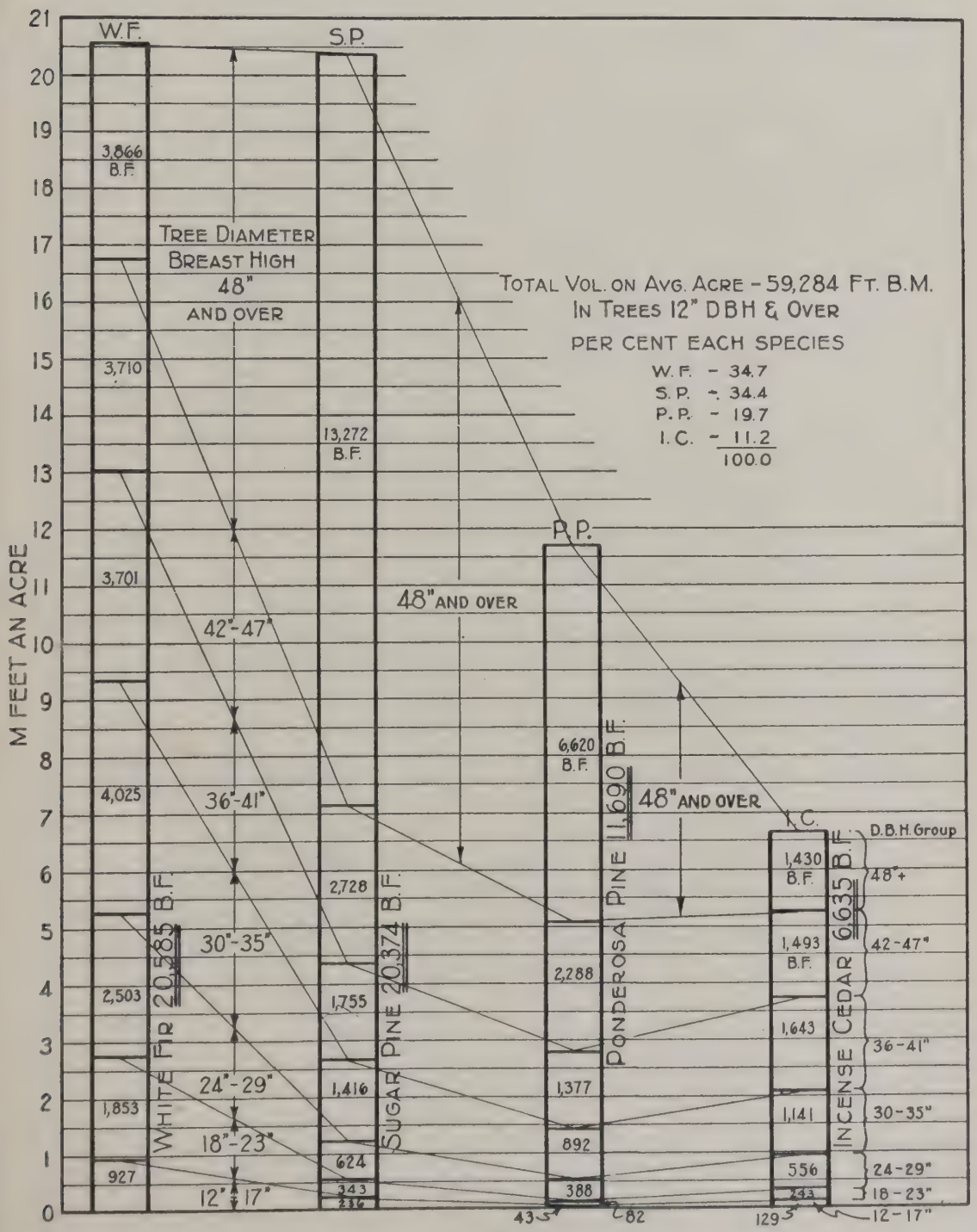


Fig. 3.—Original stand per acre on Stanislaus woods-study area. Comparative gross volumes of each species in trees 12 inches d.b.h. and over, and proportionate volumes by 6-inch diameter groups.

The extremely small proportions of total volumes in trees below 24 inches d.b.h., with the exception of white fir, is plainly brought out by figure 3. This and other facts pertaining to stand composition as shown by the diameter-group volumes and heights of bars have a very important bearing on comparative costs and values of different cutting methods.

Summarizing briefly: the study area of 73.7 acres had a gross cruised volume of 59,284 feet B.M. an acre, 54 per cent of which was sugar pine

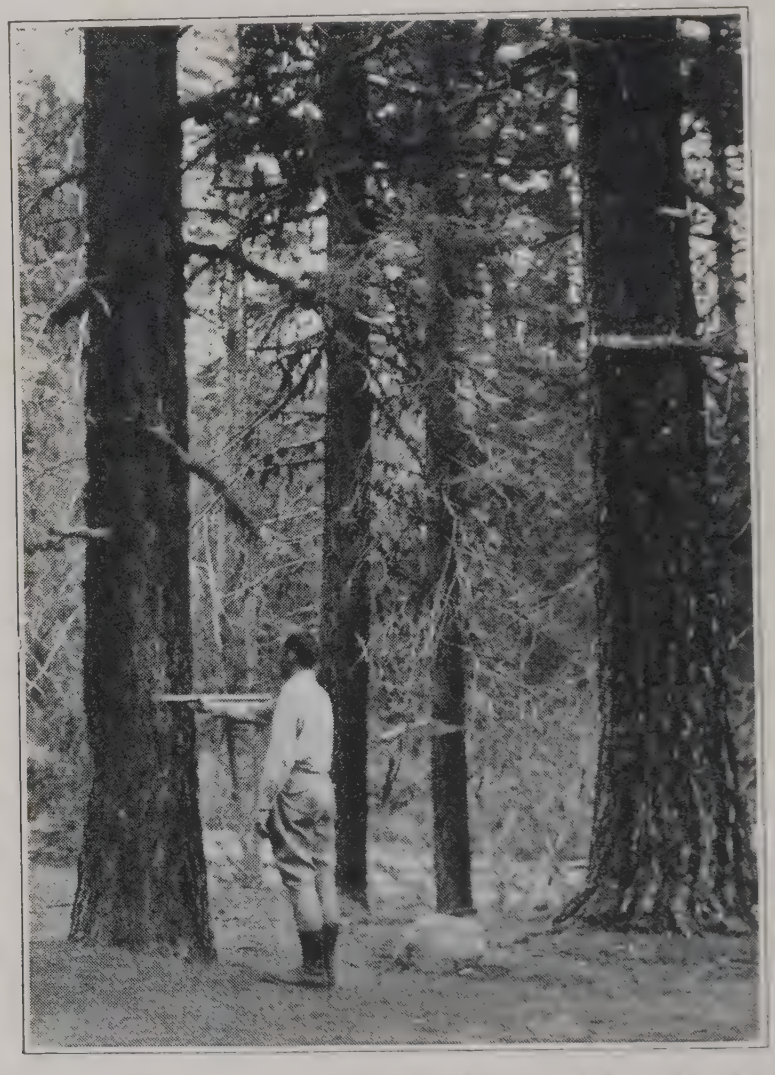


Fig. 4.—Measuring diameter breast high (d.b.h.) with cruiser's stick. The tree being measured is a 22-inch ponderosa pine, the zero-margin size in this species. (See page 51.) The larger tree on the right is a 33-inch ponderosa pine.

and ponderosa pine and 46 per cent white fir and incense cedar. Of the approximately 42 trees per acre making up this volume, one-half were under 24 inches d.b.h. The half over 24 inches contained 93½ per cent of the total volume. One-third of the entire cruised volume was in trees of the two pine species measuring 4 feet d.b.h. and over, and running from 8½ to 11 16-foot logs in merchantable height. There were about

nine of these large pines for every 4 acres, an average of 2¼ trees per acre. This means that 9 pine trees from 48 inches to 80 inches d.b.h. had the same gross scale as 79 trees, all species, ranging between 12 inches and 47 inches in d.b.h., inclusive.



Fig. 5.—On the left, a group of medium-sized, mature pines on the study area. The ponderosa pine in the foreground is about 40 inches d.b.h. On the right, one of the large, high-quality sugar pines. This specimen was 74 inches d.b.h., with 3 grade-1, 3 grade-2, and 4 grade-4 logs. The surrounding advance growth is white fir.

Log Grades.—The standard log-grading rules in use by the Forest Service for timber appraisals in the California pine region are as follows:

Grade 1: Minmum diameter 22 inches on small end and practically surface clear. One or two knots near the end of a log over 36 inches in diameter are permissible if remainder is surface clear. Smaller logs must be surface clear for the full length. Indication of knots near the surface eliminates logs from this grade as effectively as visible knots or limbs.

Grade 2 (Shop logs): Minimum diameter 18 inches on small end. Knots of any size and other blemishes are permissible provided they are so distributed as to produce lumber from which a high percentage of factory cuttings may be obtained. Seventy-

five per cent or more of the surface should be in clear areas at least 8 feet long and 6 inches or more in width, between knots or defects.

Grade 2 is not used for white fir and cedar.

Grade 3: This grade includes all logs smaller than 18 inches in diameter and larger logs too rough in appearance to be admitted in grades 1 and 2.

In this study, the diameter limits were waived and grade 3 was subdivided into grade 3 and grade 4, high-grade Common and low-grade

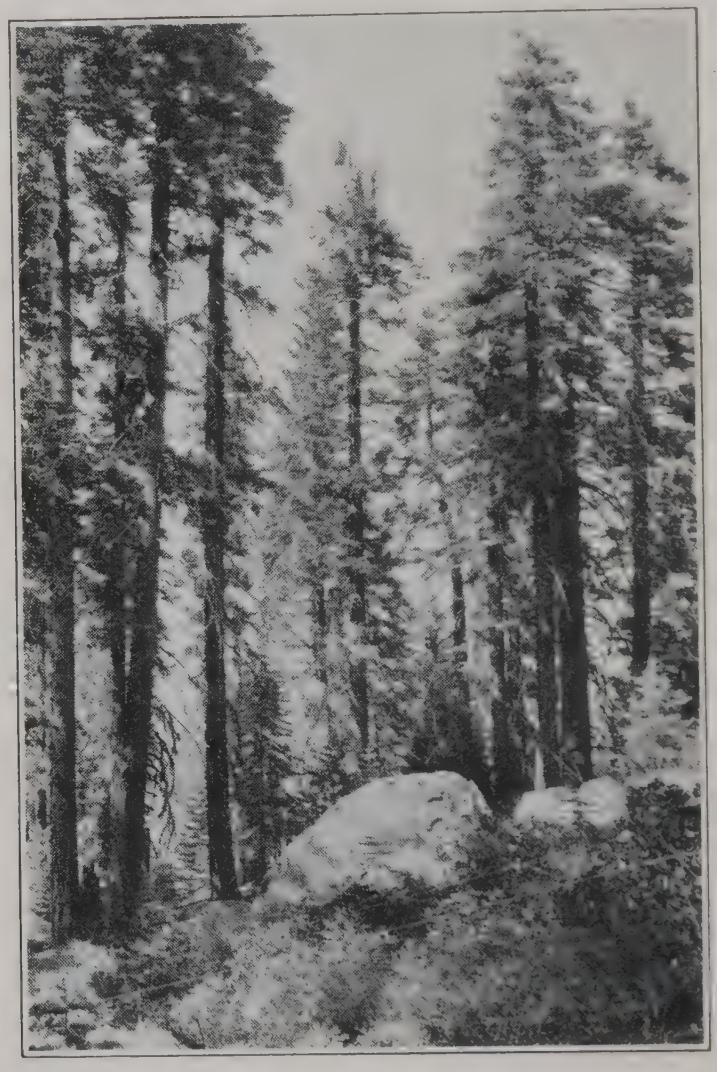


Fig. 6.—A group of mature white-fir trees on the study area. Note defective tops.

Common, respectively. This was done to permit more accurate building up of tree values. For white fir and incense cedar the larger logs which would be a high-type grade 2 in the pine species were also graded as No. 3.

As applied in the study, then, the definitions are as follows:

Grades 1 and 2: Same as above except minimum diameter limits disregarded.

Grade 3: Logs with numerous small, or pin, knots of the types permissible in the grades of No. 1 and No. 2 Common lumber and also, in white fir and incense cedar, logs with a few widely scattered, large knots giving the appearance of the best class pine Shop logs.

Grade 4: Large-knotted, coarse logs and logs with numerous small black, or dead, knots.

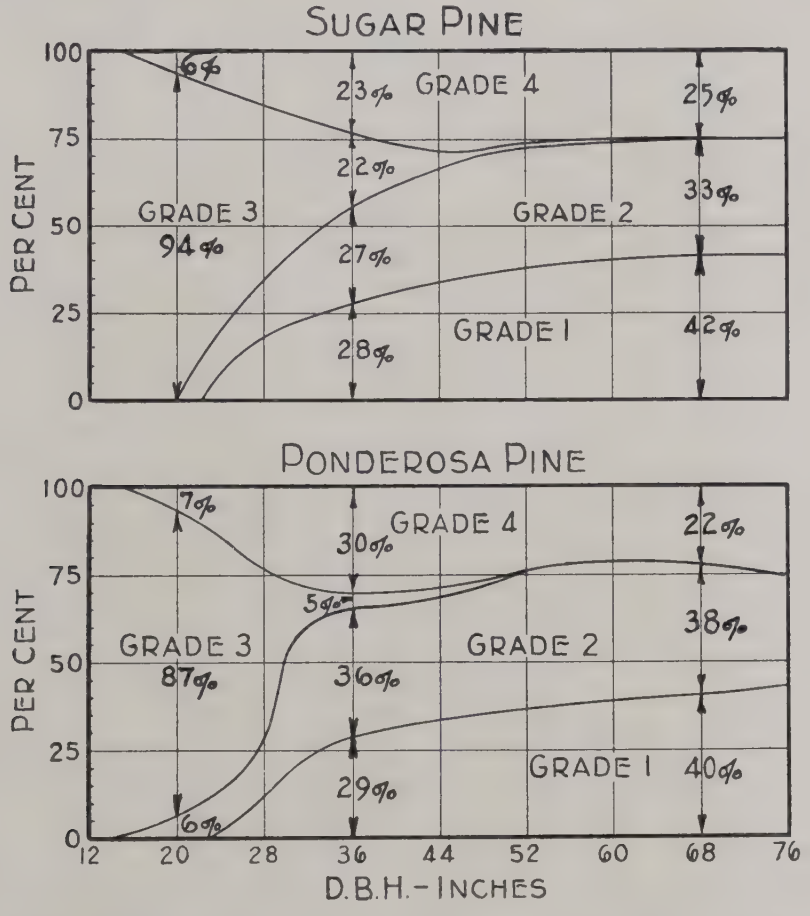


Fig. 7.—Relation of pine-tree size to quality as gauged by the percentages of volume in the various log grades. Percentages in individual log grades are indicated for 20, 36, and 68–inch trees. Cumulative percentages for any diameter may be read from the left-hand scales.

Grade 1 logs produce a high proportion of Selects; grade 2, a high proportion of upper Shop grades; grade 3 is a Common log producing a fairly high percentage of No. 1 and No. 2 Common lumber; grade 4 is the coarse, large-knotted type, producing much No. 3 Shop, No. 3 Common, and No. 4 Common.

Quality of Timber as Indicated by Log Grades.—The quality of a tree from the woodsman's point of view must be gauged by the log grades in the bole. Percentage of volume in each of four log grades for different diameters of both pine species may be read from figure 7.

It will be seen that the pine trees up to 20 inches d.b.h. were largely made up of grade-3 logs. The large pines were of high quality, the pro-

portion of total volume in grade-1 logs being about 25 per cent in the average 32-inch tree and increasing to about 45 per cent in the largest sizes.

An idea of relative average quality by species may be obtained from the following summary showing the percentage of total mill-run volume, gross scale, in various log grades:

	GRADE 1	GRADE 2	GRADE 3	GRADE 4
Sugar pine	35.2	35.3	4.3	25.2
Ponderosa pine	32.4	37.6	4.2	25.8
White fir	18.3	.....	43.2	38.5
Incense cedar	10.1	.....	30.9	59.0

Study Plots in Relation to Average Logging Areas.—A combination of special study requirements prevented the selection of random plots representing the different types, different sites, and the wide range of topographic conditions always encountered within the boundaries of any large area; consequently, when considered from the standpoint of a company's entire timber holdings, or from that of a season's cutting area, say 1,000 to 4,000 acres, the stand finally selected was somewhat above the average in acre volume and quality. There were no blank spaces or sectors of subnormal merchantibility. However, the effects of such conditions are reflected chiefly in the high selling values of the larger pines and the *average* costs for any given system of cutting and not in the costs—excluding fixed-acre charges—of handling and sawing trees or logs of a particular size class.

STUDY PROCEDURE AND BASIC DATA

Cruising, Mapping, Marking, and Tree Descriptions.—The area was cruised and mapped early in the spring of 1929. The major plot was then divided into three subplots, each to be cut in accordance with a different system. All trees 12 inches d.b.h. and over were numbered, measured, classified, examined for indications of cull and insect damage, and log-graded. The entire area was then marked by all three cutting systems so that later comparisons of relative values would not be invalidated by plot variations.

Felled-tree-analysis records were obtained after the trees were cut. In this work a crew of three measured each log with calipers and tape and drew diagrams of each tree showing breaks, unutilized tops, stump heights, etc., in addition to the data on the merchantable portion. An inventory was taken of trees below 12 inches d.b.h., advance reproduction, brush, and herbaceous vegetation before and after logging. The

three permanent subplots outlined in figure 2 will be remeasured periodically for growth of trees left; losses from windfall, insects, and other causes; development of advance reproduction; establishment of new reproduction; etc.

Felling.—Two-man felling crew time was recorded for each tree cut. Stump heights averaged about 18 inches. The trees timed totaled 926.

Limbing.—Limber's time was recorded for each tree. The trees timed totaled 926.

Bucking.—Bucker's time was recorded for each cut. The largest logs were bucked to 16 feet; the general standard length sought was 32 feet. The cuts timed totaled 1,494.

Yarding.—Caterpillar "60's" were used for yarding. They had no auxiliary equipment. All logs were hooked directly to the tractor drawbar with wire rope chokers and thus skidded from stump to landing. Tractor crew time for each turn was recorded and correlated with distance and scale of load. The trips varied from 4 small logs in one tractor load to single large-log loads requiring the combined pull of three tractors.

The distribution of yarding trips by number of tractors was:

One-tractor trips	2,552
Two-tractor trips	386
Three-tractor trips	15
Total trips timed	2,953

Number of logs in lengths as bucked for yarding	4,054
Total gross scale in yarding study, board feet	3,000,300
Volume of average woods log, gross scale, board feet	740
Number of woods-logs per M.B.M gross scale	1.35
Average volume per tractor-trip, board feet gross scale	1,016
Average volume per tractor-day, board feet gross scale	28,700
Average yarding distance, feet	731
Average external yarding distance, feet	1,200
Longest trip timed, feet	2,100

Loading.—The equipment for loading consisted of a small loading donkey with spreader bar rigging and an "American" full revolving locomotive crane with special log loading boom. End hooks were used on smaller logs, tongs on medium logs, and straps on the largest logs. About 59 per cent of the study logs were loaded with the steam winch

and 41 per cent with the crane. Time in minutes per log for different diameters used in calculating the loading costs was the average of both rigs. The crew on each rig consisted of five men. The number of logs timed was 3,481.

Transportation, Woods to Pond.—The length of haul was about 36 miles. Load records were kept for 418 cars, showing diameter, volume, and species of each log in each load. Average car-load costs were prorated to log diameters on the basis of the percentage of the average load occupied by each size of log.

Decking and Undecking.—Although all study logs were sent to the mill as soon as received from the woods, the operator's practice was to deck near the main pond the excess of daily woods production over the daily mill output, thus accumulating a supply of logs for continuing the sawmill operation for two or three months after the shutting down of woods operations by the winter storms. The total cost of decking was spread over the entire mill run. This average was then prorated to diameter by applying the same ratios of diameter costs per M.B.M. to the average cost as was shown by the loading curve.

Unloading.—Unloading costs are included with pond costs in this report.

Sawmill.—The sawmill was the double-band type, with 10-foot and 9-foot single-cut, steam-operated, head-saws. There was no gang-saw or green-lumber resaw. A steam drag-saw at the top of the log slip was used for bucking long logs into mill lengths. The carriages were equipped with air-dogs. The gang-trimmer was also air controlled. Lumber for the air-drying yard was pulled into units for transfer by overhead monorail to narrow-gauge yard cars. Mill capacity, both sides combined, was 18 to 20 M.B.M. an hour.

Two complete study crews, one for the day shift and one for the night shift, scaled, graded, and timed the sawing of the logs, marked each board for identification on the green chain, and graded, measured, and tallied the lumber.

Separate scaling, log grade and description, sawing-time, and lumber-tally forms were filled out for each log. Numbered logs from the plots were mixed in the pond with unnumbered logs coming in from other settings. Between batches of plot logs, therefore, the study crews were able to keep records for a large number of other logs, which added strength to the general run of mill data. Total pond and sawmill costs for the season were divided by the total number of effective minutes that the sawmill was in operation to obtain the cost per minute for use with the head-saw time studies.

Total volume of material studied by mill crews:

	Logs	Board Feet
Sugar pine	3,048	2,096,000
Ponderosa pine	1,886	1,111,000
White fir	2,607	922,000
Incense cedar	1,005	257,000
All species	8,546	4,386,000

Size of average log, mill run—513.2 board feet

Number of logs per M.B.M.—1.95

Lumber Production.—Lumber was tallied on the green chain by grade, thickness, width, and length. The tally form for each log was then summarized by volume in three board-width groups, viz., 4–11 inches, 12–19 inches, and 20 inches and wider, for each thickness in each grade produced. It was determined later from the depreciation study that the width price differentials, although an appreciable factor influencing relative values on a green-chain-log-tally basis, were reduced to insignificance by the much greater degrade in the wide Selects, the more extensive remanufacture given them, and the practice of making a preponderance of all-width shipments in the Shop grades; therefore the log and tree values in the charts are based on thickness and grade prices only.

Lumber Depreciation.—Representative samples of the lumber were reinspected after seasoning for accuracy of green-chain grading and for depreciation in drying. The grader marked boards for trimming and ripping to remove drying defects and to improve the original manufacture wherever it was clearly advantageous to do so. The volume of material regraded in this manner was as follows:

	Boards	Board Feet
Air dried	22,633	423,312
Kiln dried	6,259	149,407

The only planer depreciation data obtained directly in connection with the Stanislaus project were for 90 M.B.M. of white-fir boards and dimension stock. About one-third of this volume had been in storage for six months. The amount of incense cedar surfaced before shipment is negligible, hence no planer studies were considered necessary for this species. Surfacing depreciation, additional seasoning losses, and storage degrade in pine uppers were worked out from the results of special depreciation studies carried on previously by the California Forest Experiment Station at other mills in the pine region, as explained under "Additional Depreciation of Pine Species," page 25.

The data from all degrade inspections made as a part of the Stanislaus project, which showed the surfaced shipping grades for white fir, and the rough-dry shipping grades for all other species, obtained from each original green-chain grade after allowing for added defects and other changes due to trimming and ripping, were converted to final dry selling values directly applicable to the green-grade production. For

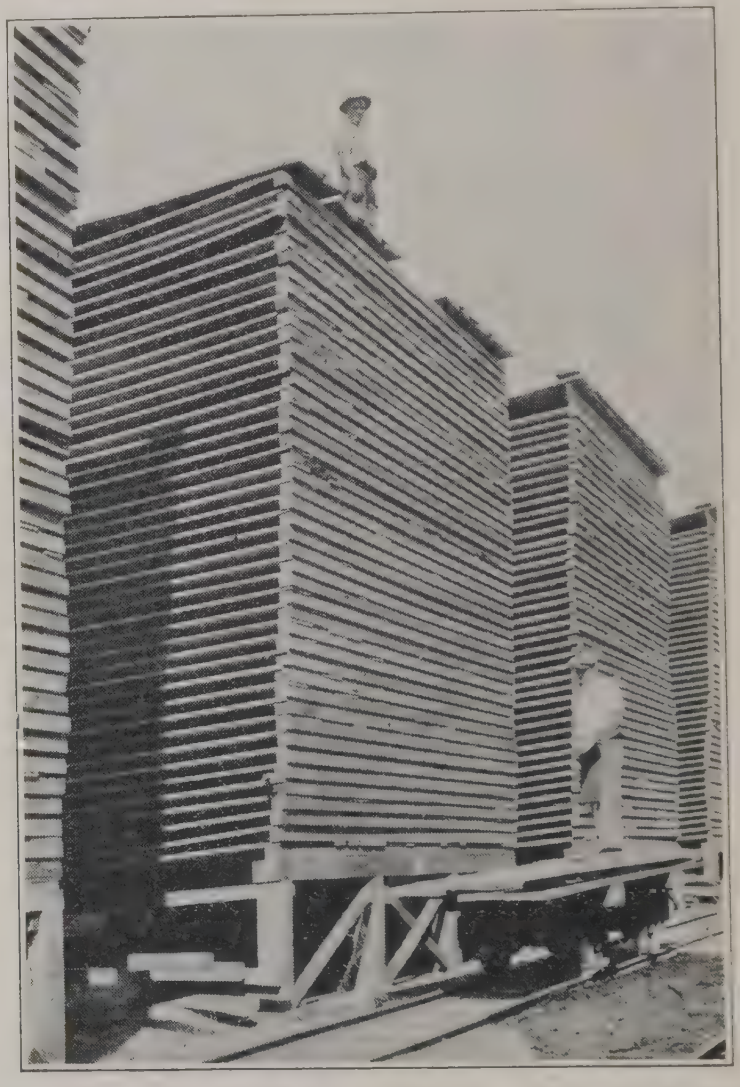


Fig. 8.—Lumber from the study logs, with the green grade marked on every board, was inspected for degrade after seasoning. This photo shows two study piles of 4/4 sugar-pine Selects just before final inspection.

example, 1 M.B.M. of 6/4-inch B and Better sugar pine as tallied in the mill study before seasoning would have a selling value, rough dry, of $82.90 if there were no degrade whatever in drying. Actually, however, some dropped to C Select, some to D Select, some to No. 3 Clear, and smaller proportions to lower grades. Eighteen board feet was lost in trims and rips. The final value of the remaining 982 board feet was $77.24. This is equivalent to the value of 1 M.B.M. green B and Better *discounted for depreciation.*

Evaluation of logs and trees on this basis permitted the use of the curved green-grade lumber-production percentages directly and the conversion of mill tally to log scale by using the green-chain overrun figures without correction for remanufacturing losses.

The relation of these discounted values to the values which would apply if no depreciation occurred between green-chain and shipping shed, is portrayed graphically in figure 9 for trees of each species and diameter. It should be kept in mind that the curves for the two pine species do not include additional depreciation in the upper grades for surfacing, stain, and storage. This has little effect on trees below 30 inches in diameter, however.

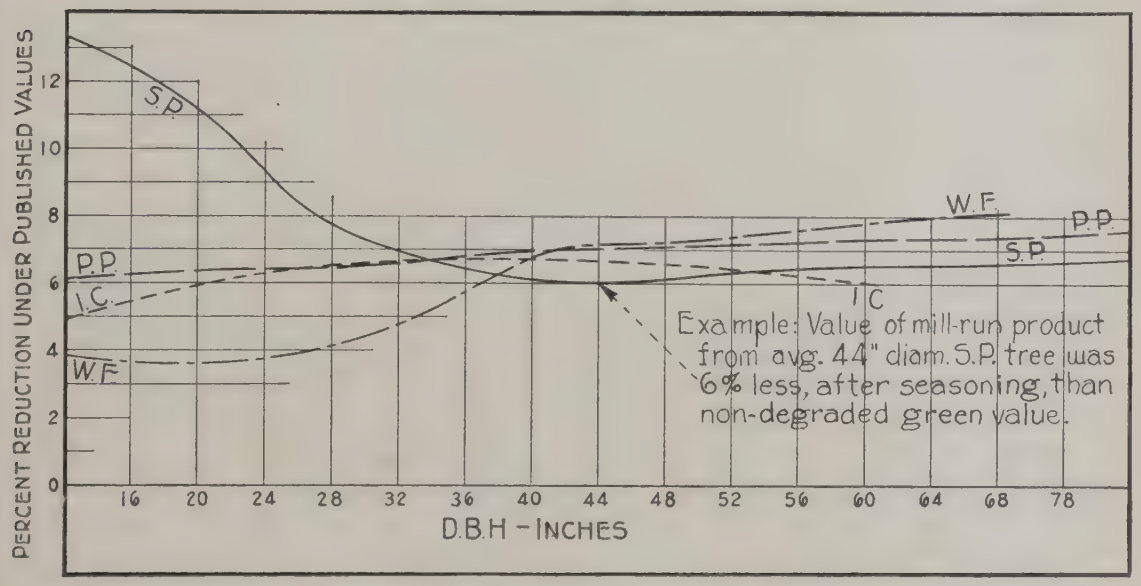


Fig. 9.—Percentage value depreciation in lumber cut from trees of different species and diameters, based on depreciation studies included in the Stanislaus project. See "Additional Depreciation of Pine Species," below, and table 13, for degrade not included in these curves for sugar-pine and ponderosa-pine trees.

Additional Depreciation of Pine Species.—The only really accurate method of determining the *average* final lumber shipping grades for each thickness and grade *as tallied on the green-chain,* particularly at mills where much of the cut is air dried, would involve long-time studies far more intensive than anything yet undertaken by any research agency, public or private, in the California region. West-slope mills usually begin cutting during March or April and continue until some time after the close of the logging season, the date depending on the number of logs stored in decks or in the pond. Storms in the mountains usually prevent further logging after the middle of November. From April to November, December, or January, then, green lumber is continuously going from sawmill to yard-pile or dry-kiln, and dry lumber is continuously going from yard-pile or dry-kiln to outside storage

piles, storage sheds, remanufacturing plant, or shipping platform. Some lumber remains in open seasoning piles for two or three seasons. Some is surfaced before shipment, some is resawed, and some is sold rough.

As all of these variations represent average regional practice, they should be taken into account when attempting to determine grade depreciation for an average season's output.

The lumber depreciation inspections of Shop and Better pine conducted as a part of this study show only the degrade from green to rough-dry during the most favorable period of the year. Board-stain and sticker-stain, causing degrade particularly in B and Better, C Select, No. 3 Clear, and No. 1 Shop are very likely to occur with spring and fall piling, as shown by previous studies at other mills cutting the same type of timber, but there was no stain whatever in the Stanislaus study material. From the results of surfacing studies made at other mills it is also known that further depreciation in value would have been incurred if the Stanislaus study pine uppers had been put through the planer. There is practically no reliable information on storage depreciation, though it is known from observation that stain is apt to be added in solid yard piles and that considerable trimming of checked ends is frequently necessary when grading yard-stored lumber for shipment.

Without going into further detail, it will be apparent to the reader that the pine lumber-grade shipping values fixed by the pine-depreciation inspections made as a part of this study, although accurate enough for lumber cut in midsummer and shipped rough-dry one to six months after stacking, are not representative of the average gross income receivable from the same green grades of lumber over a period of two or three years. Adjustments are clearly called for. They are included in this bulletin as sums to be deducted from the pine selling values calculated on the basis of the Stanislaus degrade studies alone. The deductions for logs of different diameters and grades appear in table 8 and the deductions for trees of different diameters appear in table 13. Deductions for sugar pine include also a seasoning-cost adjustment which is explained in the succeeding section. In computing these deductions, data from other depreciation studies[13] in the pine region were first combined and reduced to percentage stain-plus-surfacing value depreciation factors for each thickness and grade of lumber, storage degrade was estimated as 1 per cent additional in Select grades only, and the average deductions for logs and trees in dollars and cents were

[13] Miscellaneous unpublished reports on file in the California Forest Experiment Station.

then weighted according to the lumber grades produced from each class of logs and trees.

Adjustment of Sugar-Pine Seasoning Costs.—Interest on lumber held in the yard for long periods should perhaps be figured as a cost, especially in connection with sugar pine, to permit of a truer comparison between species. Thick sugar-pine Selects dried in the yard must be left on stickers a long time, whereas ponderosa-pine Selects dried in the kiln are ready for the market in a comparatively short time. Air-dried 16/4-inch sugar pine is rarely in suitable condition for use in less than a year. The thinner Selects require ten times as long to season in the yard as in the kiln. Sugar-pine air-drying costs from this standpoint are probably equal to or higher than kiln-drying costs for ponderosa pine. Rough adjustments to compensate for this fallacy in comparative seasoning costs for the two pine species as shown by ordinary cost accounts have been incorporated in the sugar-pine deductions given in tables 8 and 13. The adjustments are interest charges against the different grade selling values, covering the period of time required for air-drying in excess of the time required for kiln-drying the same thicknesses and grades. The rate of interest used was 6 per cent per annum.

Average Operating Costs.—Logging and milling costs for an average west-slope pine-region operation using direct tractor skidding as the yarding method, having a log haul of 36 miles over standard-gauge, privately owned railroad spurs and mainline, and cutting between 60,000 and 80,000 M.B.M. per annum in a double-band mill are summarized in table 3. The average cut per acre in the general vicinity of the study area, poor timber and good timber combined, over a period of several seasons' operation, is about 30 M.B.M. net scale, and this volume has been used in reducing fixed-acre costs to an M.B.M. basis in the table. The "Total costs per M.B.M." at the end of the table are based on an average cull deduction of 4.83 per cent and an average overrun, No. 5 Common and Better over net scale, of 7.13 per cent. It will be noted that the costs per M.B.M. net scale for different cutting diameter limits on the study plot, as given in figure 24, are all lower than the average net-scale cost in table 3. This is due, of course, to the heavier-than-average stand on the study plots and the larger-than-average size of the trees.

Costs per Minute Used in Converting Time per M.B.M. to Cost per M.B.M.—Stop-watch records of felling time per tree, bucking time per cut, sawing time per log, etc., after changing to time in minutes per M.B.M. for trees and logs of different sizes, were converted to cost per

TABLE 3

AVERAGE OPERATING COSTS FOR 3-YEAR PERIOD 1928–1930

Woods and railroad	Per acre	Per M. B. M. net scale
Felling, limbing, and bucking, Yarding, tractor skidding, Loading — including materials and supplies	.....	$ 1.22
	.....	1.61
	.....	0.58
Depreciation logging machinery, prorated to yarding and loading		0.35
General camp expense and accident compensation, prorated to all woods costs		0.68
General railroad expense, depreciation railroad equipment, and 61 per cent of maintenance	.....	0.87
Depreciation of camp buildings and equipment	$ 3.00	.....
Fire control	0.25	.....
Railroad spur construction	54.69	.....
Mainline railroad depreciation	15 00	
39 per cent of railroad maintenance	11.70	.....
Subtotal of fixed acre costs	$84.64	2.82*
Decking and undecking†	.....	0.18
Railroad transportation, 36-mile haul‡	.....	2.63
Cost of logs delivered to unloading dock	.....	$10.94

Sawmill and miscellaneous	Per M. B. M. mill tally
Unloading, pond, sawing, green sorter, kiln-stacking, and general sawmill expense, based on average mill run	$ 2.81
Selling, shipping, insurance, taxes, overhead, and plant depreciation	5.42
Narrow gauge, yard stacking, green yard, dry kiln, unstacking, delivery to shed, remanufacture, dry lumber expense, and surfacing of part, average cost for all species¶	3.30
Total, sawmill, seasoning, and miscellaneous	$11.53

Total costs per M. B. M.	Gross scale	Net scale	Mill tally
Fixed acre costs	$ 2.68	$ 2.82	$ 2.62
Woods and transportation	7.73	8.12	7.54
Sawmill and miscellaneous	11.82	12.42	11.53
Totals	$22.23	$23.36	$21.69

* On cut of 30 M. B. M. per acre.

† Mill log storage, not woods decking.

‡ Includes engine repair, car repair, and train service.

¶ Species differences were as follows:

Species	Air dried	Kiln dried	Rough	Surfaced	Cost per M. B. M.
	Per cent of total		Per cent of total		
Sugar pine	90	10	75	25	$2.65
Ponderosa pine	25	75	40	60	3.92
White fir	78	9	14	86	3 24
Incense cedar	100	0	95	5	$2.04

Remaining 13 per cent of white fir shipped green.

M.B.M. by application of the following costs per minute calculated from the current wage rates and miscellaneous expenses chargeable to each activity:

	Cost per Minute		Cost per Minute
Felling	$0.0273	Yarding	$0.1084
Limbing	0.0110	Loading	0.0950
Bucking	0.0136	Sawmill	0.4327

General camp expense and compensation insurance were prorated to each woods activity in proportion to the relative average cost of each as shown in the annual statement. The bull buck's time was prorated over all felling crews, limbers, and buckers under his supervision. Marker's time was divided equally among all the buckers for whom he marked log lengths. Tractor-boss, choker-setters, tractor-mechanic, and others whose time was chargeable to more than one tractor unit were prorated accordingly. Fuel, and depreciation of equipment are included also in the costs per minute for yarding and loading.

The total of all wages paid to the pond, sawmill, green-chain, and kiln-stacking crews for the entire 1929 season, plus charges for supplies and power used, was divided by the total number of minutes the mill was in productive operation during the season to obtain the cost per minute for both head-rigs combined. This amounted to $0.8655, one-half of which was prorated to each head-rig. Each M.B.M. of mill production for the season absorbed an equal share of plant depreciation, so the latter item is not included in the sawmill cost per minute.

Lumber for the kiln was not pulled from the green chain, but was carried automatically from the end of the table to the kiln stacking shed. Green-chain costs per M.B.M. on the volume pulled for air drying, and kiln-stacking costs on the volume not pulled, were very nearly the same. Handling the costs as above noted is practically equivalent to a full green-chain charge prorated by log diameter to the entire mill output, with no added expense in the kiln-drying costs for stacking the proportion kiln dried.

Lumber Selling Prices.—The California White and Sugar Pine Manufacturers' Association selling-price summaries for the calendar years 1928, 1929, and 1930 are the basis of the average values per M.B.M. shipping tally appearing in tables 4 and 5. The Association prices are for surfaced lumber (except incense cedar Pencil), so in calculating the values of the proportions sold in the rough condition, certain deductions must be made. These are given in footnotes beneath the tables. As explained on page 24, these shipping-tally selling values were discounted for depreciation before application to the green-grade production of logs and trees.

TABLE 4

AVERAGE LUMBER SELLING PRICES* OF SUGAR PINE AND PONDEROSA PINE FOR 3-YEAR PERIOD 1928–1930 PER M.B.M. SHIPPING TALLY

Grade	Thickness in inches					
	4/4	5/4	6/4	8/4	10/4	16/4
Sugar-pine values						
B and Better	$94.85	$93.14	$85.90	$97.04	$126.65	$140.30
C Select	82.33	75.78	65.67	79.59	120.09	133.12
D Select	66.12	57.14	48.28	66.16	97.27	110.75
3 Clear	48.17	60.51	60.02	77.67	113.92	125.27
Inch Shop	$38.18	.....	.....	.....	.....	.....
1 Shop	.....	42.98	41.77	57.66	90.95	105.58
2 Shop	.....	30.92	29.24	35 31	50.15	$ 68.91
3 Shop	.....	$23.22	$23.21	$23.05	$ 36.25	.....
Ponderosa-pine values						
B and Better	$70.64	$71.95	$68.30	$76.97	$105.56	$120.79
C Select	65.89	61.75	54.94	64.99	97.40	112.81
D Select	52.95	48.61	40.58	50.63	79.30	95.20
3 Clear	37.35	50.56	50.17	62.24	99.86	113.96
Inch Shop	$28.64	.....	.....	.....	.....	.....
1 Shop	.....	34.83	33.64	46.25	79.24	92.08
2 Shop	.....	25.22	25.00	31.72	46.17	62.40
3 Shop	.....	$20.03	$21.42	$22.02	$ 34.18	$ 49.56
Mixed-pine values						
1 Common	$42.98	$48.35	.....	.....	.....	.....
2 Common	28.52	32.12	$32.12	$31.63	.....	.....
3 Common	20.72	22.41	22.41	23.92	.....	.....
4 Common	$15.04	$16.01	$16.01	$19.02	.....	.....
5 Common	All thicknesses—$8.62					

* Average selling prices as summarized by the California White and Sugar Pine Manufacturers' Association are for surfaced lumber. The rough-dry prices may be obtained by deducting $3.00 from the values given in the table for the grades of B and Better, C Select, D Select, and No. 3 Clear, $2.00 from the values for No. 1 Shop and No. 2 Shop, and $1.00 from the values given for all other grades.

CULL AND OVERRUN

As this bulletin is not intended for use in making appraisals on other areas, it is not important to present the cull and overrun percentages for each size and species of logs and trees. Use of the Scribner Decimal C log rule for scaling the study logs resulted in the usual high percentages of overrun for the smallest logs and trees.

Table 6 summarizes the percentages of overrun and cull for each species as a whole. Incense cedar had the greatest excess of No. 5 Common and Better tally over net scale and ponderosa pine the least. This was due chiefly to the average thicknesses of lumber cut, over 90 per cent of the cedar being sawed to 10/4-inch pencil stock, while ponderosa pine

TABLE 5

AVERAGE LUMBER SELLING PRICES* OF WHITE FIR AND INCENSE CEDAR FOR 3-YEAR PERIOD 1928–1930 PER M.B.M. SHIPPING TALLY

White-fir values

Grade	Thickness in inches				
	4/4	6/4 and thicker	1 11/16 and 1 5/8	1 3/4 and thicker	All thicknesses
C and Better	.....	.....	.....	.....	$39.92
3 and Better Common	$19.98	$21.03	.....	.....	.....
4 Common	13.51	15.79	.....	.....	.....
1 Dimension	.....	.....	$18.53	$25.54	.....
2 Dimenion	.....	.....	14.74	19.86	.....
2 and Better Dimension	.....	.....	16.34	19.15	.....
3 Dimension	.....	.....	$10.50	$12.70	.....
5 Common	.....	.....	.....	.....	$ 7.38

Incense-cedar values

Grade	10/4	All thicknesses
C and Better	.....	$50.40
3 and Better Common	.....	20.50
4 Common	.....	12.40
5 Common	.....	$ 7.38
1 Pencil*	$25.40	.....
2 Pencil*	12 00	.....

* All prices are for surfaced lumber except No. 1 and No. 2 Pencil. Deduct $3.00 from C and Better and $1.00 from other grade values, except for the Pencil grades, to obtain rough selling prices.

was sawed principally to 4/4, 5/4, and 6/4-inch lumber, with a much greater proportion of 4/4 and 5/4-inch material than either sugar pine or white fir.

TABLE 6

CULL AND OVERRUN PERCENTAGES* BY SPECIES

Species	All trees 12 inches in diameter and over			All trees 40 inches in diameter and over		
	Cull percentage	Overrun percentage		Cull percentage	Overrun percentage	
		Net scale basis	Gross scale basis		Net scale basis	Gross scale basis
Sugar pine	5.19	4.57	−0.85†	5.69	4.62	−1.34†
Ponderosa pine	2.73	2.42	−0.38†	2.89	2.49	−0.48†
White fir	4.44	5.58	0.89	6.80	5.49	−1.68†
Incense cedar	11.82	29.12	13.86	18.56	31.70	10.30
All species	4.96	6.30	1.03	5.84	5.65	−0.51†

* Cull percentages are based on the volumes scaled at the mill. Cull logs and breakage left in the woods are not included. Overrun percentages are for No. 5 Common and Better.

† Minus sign indicates underrun.

Green trees with less than 25 per cent of merchantable net scale, i.e., cull trees, are not included in the table-6 figures. This class of standing timber, commonly referred to as "sanitation trees" on Forest Service timber sales, need not be utilized under government regulations although its cutting is required for stand improvement. Cull trees in incense cedar averaged a little under one tree to the acre. There were no unmerchantable trees, under this definition, in the other species, hence the cull and overrun figures refer to the entire original stand of sugar pine, ponderosa pine, and white fir on the study plot. For incense cedar they refer to 8.03 trees, out of the original stand of 8.82 trees to the acre.

LOG COSTS, VALUES, AND MARGINS

Itemized Costs in Relation to Log Diameters.—On a day-wage basis, all costs for felling, limbing, bucking, yarding, loading, and sawing may be reduced to a fixed sum-per-minute of effective time, irrespective of output during that time. The cost to be charged against a particular log will depend on the number of minutes required to complete the operation for that log. Time in minutes multiplied by cost per minute gives the log cost. The log cost divided by the M.B.M. scale[14] or tally gives the cost per M.B.M. The significance of log size when appraised by this method is portrayed graphically in figure 10 by separate curves of costs per M.B.M. for bucking, yarding, loading, decking, and sawing. A curve of log-transportation costs is also included. Variation in the latter is not determined by time studies, but log diameter has its effect, nevertheless, because the pay-load capacity of a car in M.B.M. is less for small than for large logs.

Five of the curves are for sugar-pine logs and one is for all species combined. Costs for the other species were practically the same as those for sugar pine as far as woods costs are concerned. In the sawmill, white-fir costs were slightly lower than those for sugar pine, incense-cedar costs were appreciably lower, and ponderosa-pine costs were somewhat higher. All, however, showed the same marked tendency to rise very sharply with decrease in log diameters below 20 inches.

The term "woods logs" in the charts refers to average lengths as bucked for yarding. Subsequent bucking of long logs into mill lengths was accomplished by a steam drag-saw at the top of the slip.

Costs per M.B.M. for different diameters of logs in figure 10 are on a gross-scale basis with the exception of the sawing curve, which is based on the green-chain tally of No. 5 Common and Better lumber.

[14] All log-scaling in this study was done with the Scribner Decimal C log-rule.

Compared with the costs per M.B.M. gross scale for 30-inch woods logs, bucking costs were 40 per cent higher for 20-inch, and 191 per cent higher for 10-inch logs; yarding (tractor skidding) costs[15] were 29 per cent higher for 20-inch and 291 per cent higher for 10-inch logs; loading costs were 90 per cent higher for 20-inch, and 602 per cent higher for

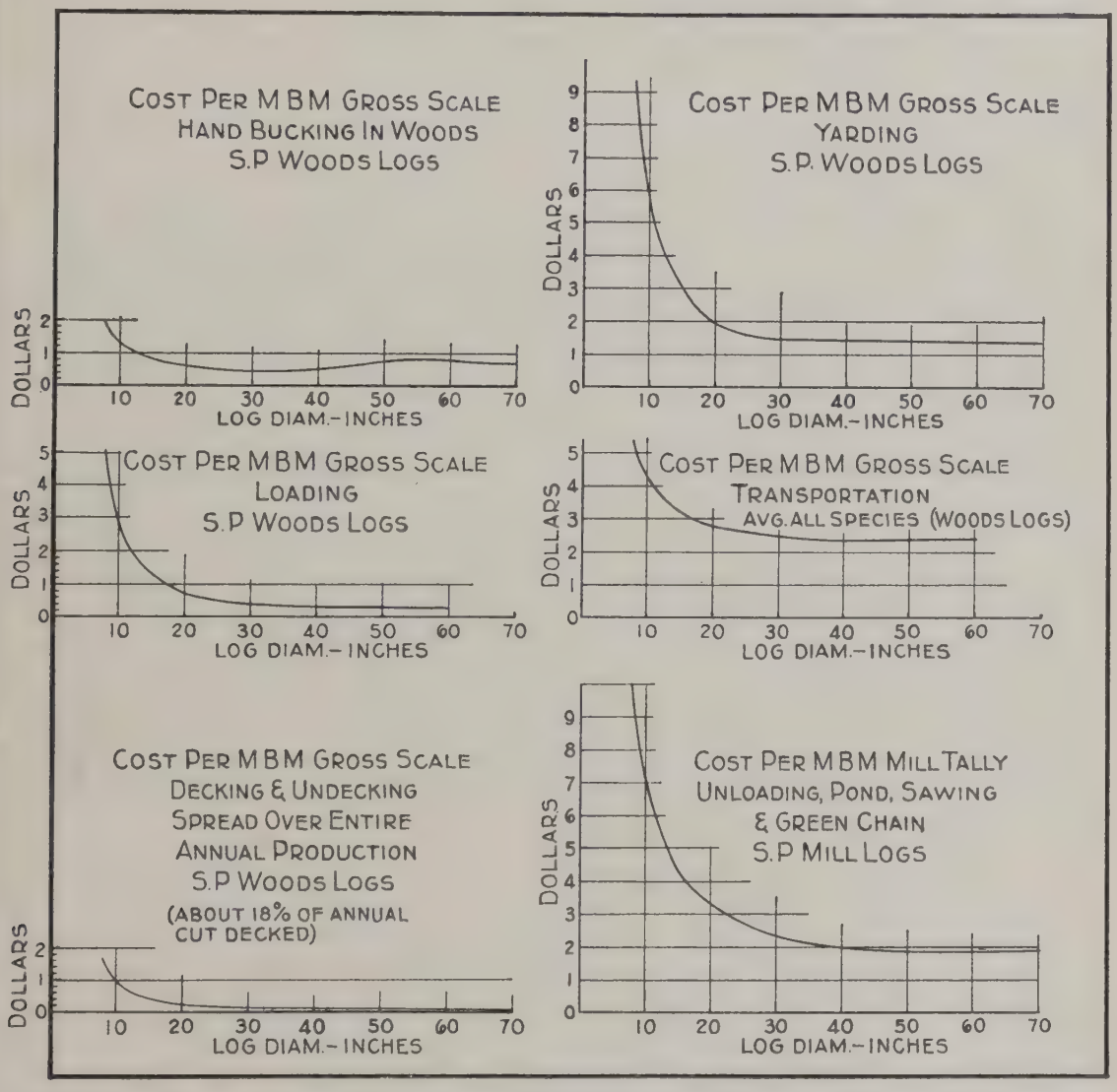


Fig. 10.—The relation of costs per M.B.M. to log diameter. Note the sharp rise of each cost curve over the smaller diameters. Five of the curves reproduced in this figure are for sugar-pine logs (designated "S.P."). Cost curves for the other species were very similar.

10-inch logs; railroad transportation costs were 10 per cent higher for 20-inch and 69 per cent higher for 10-inch logs. Compared with the costs per M.B.M. mill tally for 30-inch mill logs, pond and sawmill costs were 41 per cent higher for 20-inch and 194 per cent higher for 10-inch logs.

[15] Prorating of tractor-trip costs to log diameters in mixed loads was worked out for this report by the method of least squares. Cost per car for railroad transportation was prorated by the same method.

Decking costs at the sawmill, where the smaller and lower-grade logs were stacked for winter sawing, were prorated to diameters on the basis of the loading-cost curve since the two activities were fairly similar as to labor and equipment used.

But the question of most vital importance to the lumber operator in respect to the logs to be cut and delivered to his mill cannot be answered by analysis of costs alone. For each size class and grade of logs he wants to know how the cumulative total of *all costs* compares with the *selling value* of the lumber produced.



Fig. 11.—Direct tractor skidding from stump to landing—the type of yarding employed on the Stanislaus study area.

Explanation of Cost and Value Curve Diagrams for Logs.—In determining the size of the smallest log just paying its own way, only those costs which will be incurred *after* the tree is felled and ready for bucking should be deducted from the selling value. Felling and limbing costs, therefore, should be temporarily tabled, along with fixed acre expense, for later consideration.

Figures 12, 13, 14, and 15 combine the costs per M.B.M. of bucking, yarding, loading, transportation, decking, unloading, pond, sawmill, seasoning, overhead, and miscellaneous fixed M.B.M. expenses, all on a mill-tally, mill-log basis, for each log diameter of each species in curves labeled, "woods plus mill costs." Broken-line curves of "woods costs" have been inserted to indicate the line of demarcation between bucking-to-pond and pond-to-lumber-shipping costs. Selling-value curves for each log grade in the same diagrams show clearly the relation between costs and values for every diameter. The selling value of 1 M.B.M.

green-chain tally for any size and grade may be read directly from the left-hand dollar scale. Deducting from this figure the "woods plus mill cost" for the same size, read from the same scale, leaves the sum representing the gross margin between operating costs, starting with bucking, and selling value as calculated from the production and seasoning studies.

The more important factors influencing basic costs and values which were described in preceding sections are repeated here for ease of reference by the reader when reviewing the charts and tables.

1. The method of yarding was entirely direct tractor skidding; there was no big-wheel, fairlead-arch, or other special equipment.

2. The average skidding distance was about 750 feet on the study area. The longest hauls were 2,000 to 2,100 feet, but the average external distance from the landings was about 1,200 feet. All yarding costs are for the average skidding distance.

3. Length of log haul over standard-gauge railroad to the mill was 36 miles.

4. Method of sawing was entirely a headsaw operation. There was no gangsaw or green cant resaw.

5. Lumber selling prices used are the averages for 1928–1930. Wage rates, etc., are for the same period.

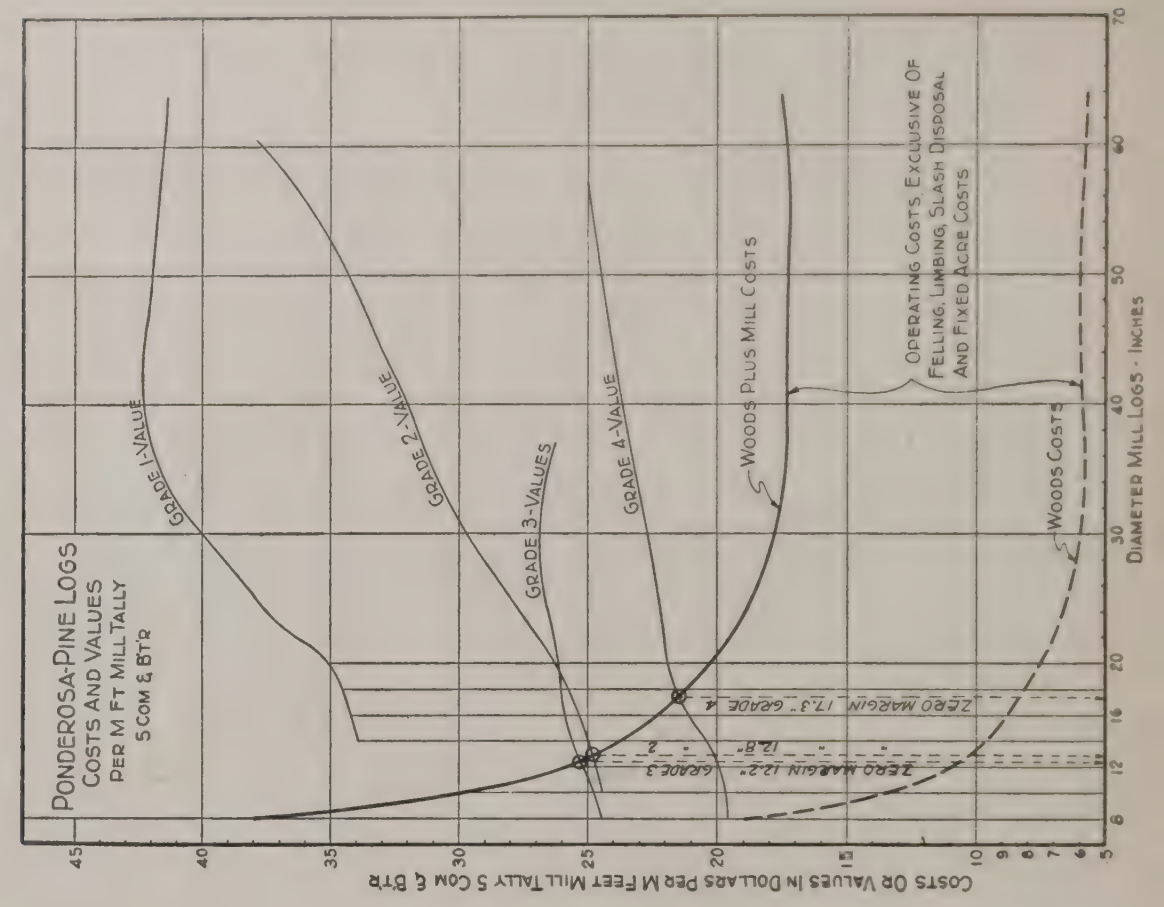
Cumulative Costs for Logs.—Relative costs of logging and milling different sizes of logs of each species are given in table 7. These are identical with the chart cost-curve values, and do not include felling, limbing, fixed-acre cost, or stumpage.

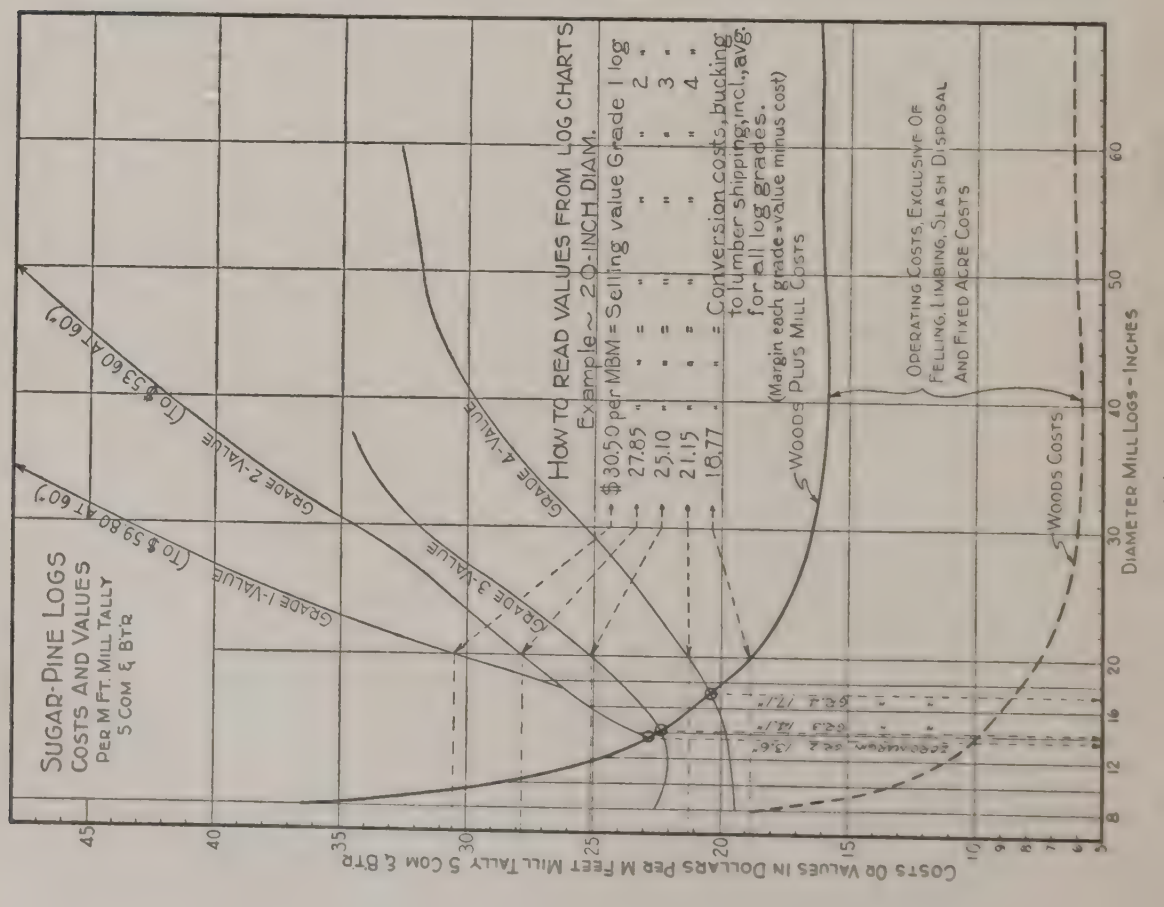
TABLE 7

Relative Costs per M.B.M.* for Logs of Different Diameters

Mill-log diameter in inches	Sugar pine	Ponderosa pine	White fir	Incense cedar
8	$36.51	$37.89	$36.99	$34.95
10	28.51	29.83	28.63	28.46
12	24.78	25.94	25.77	23.01
14	22.48	23.77	22.86	20.60
16	21.06	22.39	21.21	18.79
18	19.89	21.27	20.05	17.27
20	18.77	20.27	18.81	16.21
30	16.43	17.82	17.20	15.22
40	15.86	17.34	16.62	$15.65
50	16.02	17.25	$16.70	.....
60	16.15	$17.36	.....	.....
70	$16.15	.....	.....	.....

* Bucking to lumber shipping, inclusive. All costs are on an M. B. M. green lumber tally basis, No. 5 Common and Better.


PONDEROSA-PINE LOGS
COSTS AND VALUES
PER M FT MILL TALLY
SCOM & BTR
GRADE 1-VALUE
GRADE 2-VALUE
GRADE 3-VALUES
GRADE 4-VALUE
WOODS PLUS MILL COSTS
OPERATING COSTS, EXCLUSIVE OF FELLING, LIMBING, SLASH DISPOSAL AND FIXED ACRE COSTS
WOODS COSTS
ZERO MARGIN 17.3" GRADE 4
ZERO MARGIN 12.2" GRADE 3
12.8" " " 2
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY S COM & BTR
DIAMETER MILL LOGS - INCHES


SUGAR-PINE LOGS
COSTS AND VALUES
PER M FT. MILL TALLY
SCOM & BTR
GRADE 1-VALUE (TO $ 59 80 AT 60')
GRADE 2-VALUE (TO $ 53 60 AT 60')
GRADE 3-VALUE
GRADE 4-VALUE
HOW TO READ VALUES FROM LOG CHARTS
Example ~ 20-INCH DIAM.
→ $ 30.50 per MBM = Selling value Grade 1 log
→ 27.85 " = " " " 2 "
→ 25.10 " = " " " 3 "
→ 21.15 " = " " " 4 "
→ 18.77 " = Conversion costs, bucking to lumber shipping, incl., avg. for all log grades. (Margin each grade = value minus cost)
WOODS PLUS MILL COSTS
OPERATING COSTS, EXCLUSIVE OF FELLING, LIMBING, SLASH DISPOSAL AND FIXED ACRE COSTS
WOODS COSTS
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY S COM & BTR
DIAMETER MILL LOGS - INCHES

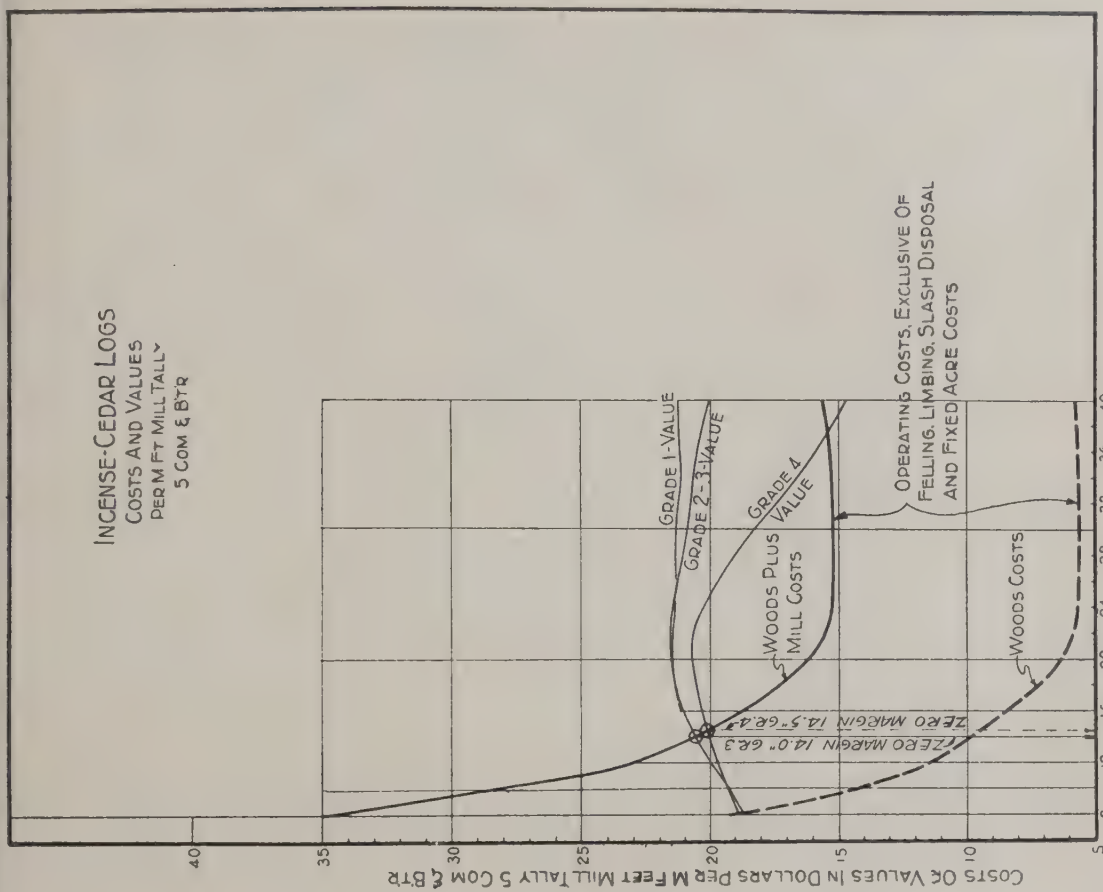

INCENSE-CEDAR LOGS
COSTS AND VALUES
PER M FT MILL TALLY
5 COM & BTR
GRADE 1-VALUE
GRADE 2-3 VALUE
GRADE 4 VALUE
WOODS PLUS MILL COSTS
OPERATING COSTS, EXCLUSIVE OF FELLING, LIMBING, SLASH DISPOSAL AND FIXED ACRE COSTS
WOODS COSTS
ZERO MARGIN 14.5"-GR.4
ZERO MARGIN 14.0"-GR.3
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY 5 COM & BTR
DIAM MILL LOGS-INCHES

Fig. 15

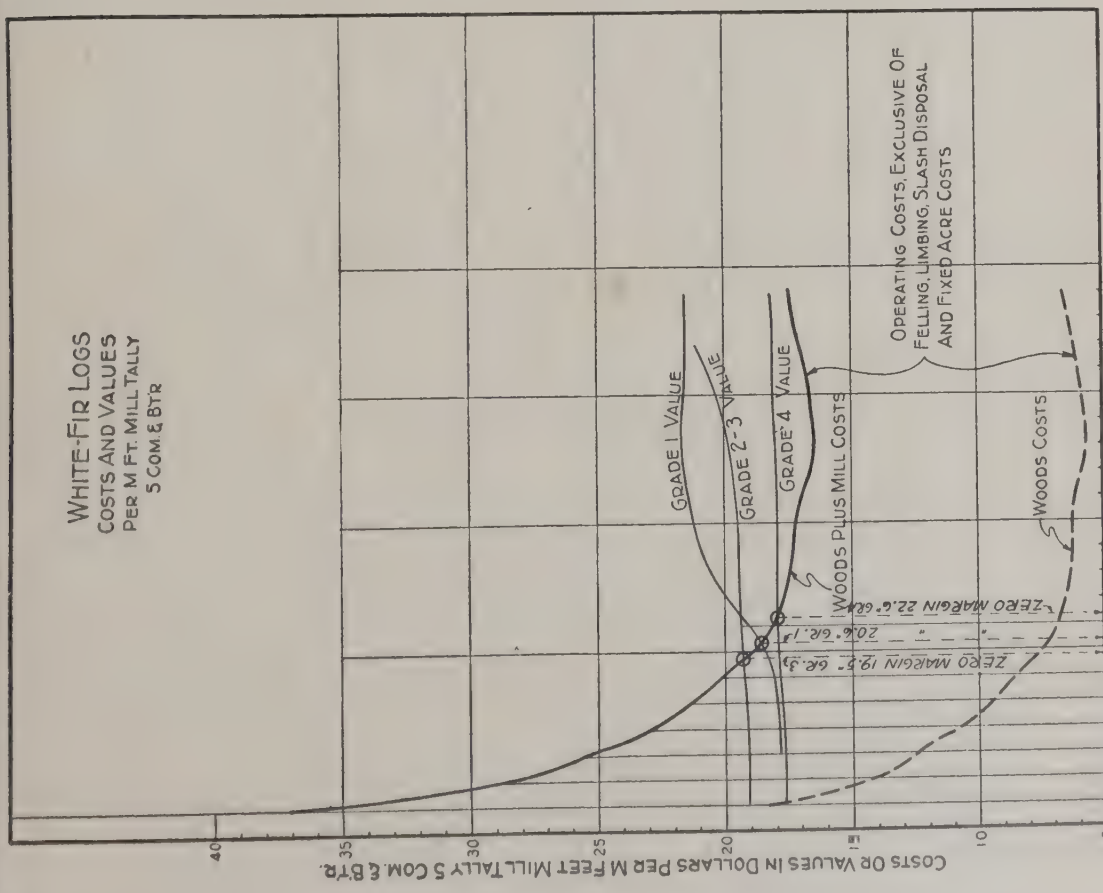

WHITE-FIR LOGS
COSTS AND VALUES
PER M FT. MILL TALLY
5 COM & BTR
GRADE 1 VALUE
GRADE 2-3 VALUE
GRADE 4 VALUE
WOODS PLUS MILL COSTS
OPERATING COSTS, EXCLUSIVE OF FELLING, LIMBING, SLASH DISPOSAL AND FIXED ACRE COSTS
WOODS COSTS
ZERO MARGIN 22.6"-GR.4
20.6"-GR.1
ZERO MARGIN 19.2"-GR.3
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY 5 COM. & BTR.
DIAMETER MILL LOGS-INCHES

Fig. 14

Differences in total bucking-to-lumber-shipping costs per M.B.M. due to differences in diameter, as shown by the log cost curves and the summary in table 7, were very similar for all species.

Total costs per M.B.M., bucking to lumber shipping, inclusive, *more than doubled* with decrease in log diameter to 8 inches from an average of about 40 inches.

The increase in costs per M.B.M. was equivalent to an average of about 64 cents per inch of decrease between these sizes. The percentage of increase in costs per M.B.M., by 10-inch log diameter intervals, was:

3.6 per cent from 40 inches to 30 inches
14.2 per cent from 30 inches to 20 inches
51.9 per cent from 20 inches to 10 inches

Values per M.B.M. for Logs.—The selling values per M.B.M. of different species, grades, and sizes of logs may be read from the value curves in figures 12 to 15. They have not been recapitulated in tabular form because of the large number of segregations involved. Curved values in the sugar-pine and ponderosa-pine charts are depreciated for seasoning degrade only to the extent determined from the rough-dry inspections described previously under "Lumber Depreciation," page 23. Additional deductions on account of surfacing, stain, and storage degrade, based on other depreciation studies in the pine region, are given in table 8. Adjustments to compensate for the absence of carrying charges on air-dried sugar pine Selects and Shops (see "Adjustment of Sugar Pine Seasoning Costs," page 27) so the comparison between sugar-pine and ponderosa-pine margins will be valid, have been incorporated with the data in table 8. These latter adjustments are practically equivalent to the application of kiln-drying costs to all sugar-pine uppers.

It is evident from the selling-value curves (figs. 12–15) that the greatest variations in value per M.B.M. with differences in log diameter occurred in sugar pine, the least in white fir. With a few exceptions the variations were continuous decreases in value from large to small sizes. The only exception of any real significance from the economic standpoint was found in incense cedar, where the maximum value for grade 4 logs occurred at about 22 inches and from this point decreased more rapidly with increase in diameter than with decrease in diameter.

Zero-Margin Diameters for Logs.—Where the "Woods Plus Mill Cost" curves cross the log-value curves, production cost and selling value are equal. The sizes where this occurs may be read from the lower chart scales by following the vertical lines extended downward from the points of intersection in figures 12, 13, 14, and 15. Since value minus cost for these diameters was zero, they are termed the "zero-margin

TABLE 8

DEDUCTIONS PER M.B.M. FOR SURFACING, STAIN, AND STORAGE DEGRADE:* TO BE TAKEN FROM CURVED VALUES FOR SUGAR-PINE AND PONDEROSA-PINE LOGS

Mill-log diameter in inches	Log grades			
	1	2	3	4
Sugar-pine logs				
10	.....	.....	$0.00	$0.00
14	.....	.....	0.00	0.00
16	.....	$0.10	0.22	0.00
18	$0.20	0.35	0.50	0.00
20	0.70	0.61	0.90	0.30
26	2.18	1.60	1.70	1.35
30	2.75	2.18	1.99	1.80
40	3.58	3.00	2.55	2.25
50	3.99	3.57	.....	2.50
60	4.18	3.85	.....	2.60
70	4.25	3.94	.....	.....
Ponderosa-pine logs				
10	.....	.....	0.00	0.00
14	.....	0.00	0.00	0.00
16	1.41	0.30	0.37	0.00
18	1.52	0.58	0.60	0.00
20	1.60	0.75	0.88	0.25
26	1.81	1.26	1.38	0.82
30	1.98	1.52	1.59	1.10
40	2.10	1.88	$1.75	1.35
50	2.19	2.05	.....	1.40
60	$2.19	$2.20	.....	$1.39

*Including adjustments of comparative seasoning costs. See "Additional Depreciation of Pine Species," page 25, and "Adjustment of Sugar Pine Seasoning Costs," page 27.

diameters'' and represent the sizes which just paid their way after the trees were felled and limbed. These zero-margin sizes are recapitulated in table 9.

Log length as bucked prior to skidding is, of course, an important factor affecting woods costs per M.B.M. All results expressed in terms of the mill-log-diameter variable alone, therefore, are necessarily subject to change with any changes in the basic woods lengths involved in the calculations. Roughly, the average woods length for the diameters shown in table 9 was between 26 and 28 feet. On a woods-log basis, logs smaller in diameter than the zero-margin sizes given in table 9 will ''break even'' if they are longer than this average length. If shorter, the zero-margin diameters will be somewhat greater. The diameter factor

alone does not provide an exact index of marginal values, but it is reasonably satisfactory as a basis for showing the general trends of size-margin relations.

TABLE 9

ZERO-MARGIN LOG DIAMETERS ON THE STANISLAUS STUDY AREA

Log grade	Sugar pine	Ponderosa pine	White fir	Incense cedar
	Diameter small end, inches			
1	.....*	.....*	20.6	.....*
2	13.6	12.8	.....†	.....†
3	14.1	12.2	19.5	14.0
4	17.1	17.3	22.6	14.5‡

* All sizes profitable. Grade-1 logs are rarely found smaller than 20 inches in the west-slope pine region.

† Shop-type logs were graded as No. 3 in fir and cedar.

‡ As shown in figure 15, there was also a *maximum* zero margin for grade-4 incense cedar logs at approximately 37.5 inches.

Log Margins.—For logs of diameters greater than the zero-margin sizes, the difference in dollars between "value" and "woods plus mill costs" curves in figures 12, 13, 14, and 15, represents the sum per M.B.M. available from the selling value of each diameter class and log grade—after deducting all costs incurred between bucking and shipping—for:

1. Fixed acre costs
2. The expense of felling and limbing
3. Slash disposal costs
4. Stumpage
5. Interest and profit
6. In the two pine species only, additional losses from surfacing, stain, and storage degrade.

The margins for pine logs, after making the value corrections called for by item 6 above, are given in table 10. White-fir and incense-cedar curved values need no further adjustment.

The margins in table 10 and the margins for white-fir and incense-cedar logs obtained by reading the differences between the cumulative bucking-to-lumber-shipping cost curves ("woods plus mill costs") and the value curves in figures 14 and 15, show that decreasing values through the lower diameter range, combined with increasing costs, resulted in cash losses ranging from a few cents to almost twenty dollars per M.B.M. in the small sizes, *the greatest net losses being incurred on the logs of very small diameters, which are cut principally from the smaller sizes of trees.*

TABLE 10

Corrected Margins* per M.B.M. for Sugar-Pine and Ponderosa-Pine Logs

Mill-log diameter in inches	Log grade			
	1	2	3	4
	Sugar-pine logs			
10	.....	.....	—$6.36†	—$8.96†
14	.....	.....	— 0.08†	— 2.68†
16	.....	$ 4.14	1.67	— 1.01†
18	$ 6.51	6.36	3.56	0.81
20	10.83	8.42	5.53	2.43
26	19.61	12.74	10.49	5.14
30	24.12	15.89	13.53	7.12
40	33.61	22.94	16.59	11.54
50	37.79	28.36	.....	13.38
60	39.52	33.40	.....	13.75
70	42.30	36.89	.....	.....
	Ponderosa-pine logs			
10	.....	— 5.43†	— 5.05†	—10.20†
14	.....	1.23	1.83	— 3.37†
16	10.40	2.64	3.11	— 1.31†
18	11 76	3.90	4.17	0.32
20	13.17	5.26	5.03	1.38
26	18.04	8.61	6.90	3.08
30	20.20	10.30	7.41	3.78
40	22.89	12.76	$ 6.52	4.95
50	22.54	14.95	.....	5.78
60	$21.95	$18.07	.....	$ 6.45

* Margins per M. B. M. mill tally No. 5 Common and Better obtained by deducting "woods plus mill costs" as shown in figures 12 and 13, from log-grade values in the same figures, and then reducing these further by the amounts given in table 8. The margins in this table, therefore, are corrected for all types of lumber depreciation and incorporate seasoning cost adjustments.

† Minus sign indicates operating loss.

TREE COSTS, VALUES, AND MARGINS

Relation of Tree Diameter to Lumber Grades Produced.—On page 19, the proportions of the total gross scale of trees in the different log grades were briefly outlined as an index of timber quality on the study area. This hardly conveys an adequate picture of the reason for tree-value fluctuations, however, for logs of the same grade also fluctuate in value with changes in size. Differences in yield of the various grades of lumber from different sizes of trees are the real basis of value increases and decreases.

In the calculations of log and tree values for the study, there were 50 segregations in sugar pine, 40 in ponderosa pine, 18 in white fir, and 6 in

incense cedar for lumber grades and thicknesses. They are too numerous to be tabulated fully in relation to log and tree sizes, but if the thickness segregations are dropped, the lumber grades alone can be shown diagrammatically for average trees of each diameter and species so as to bring out forcefully the fundamental relations between outside size and inside quality.

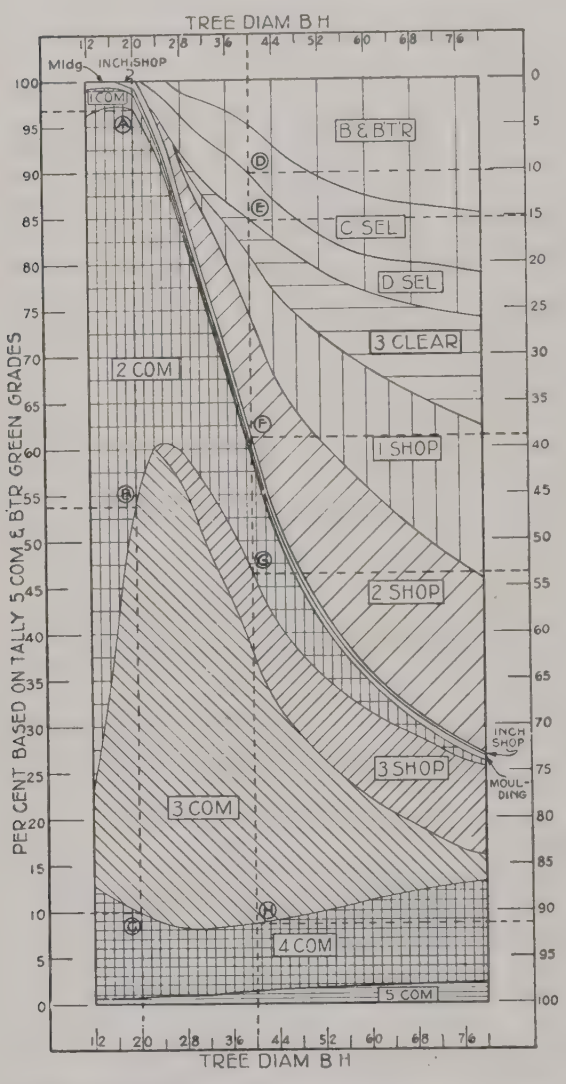


Fig. 16.—Green-lumber-grade production in sugar-pine trees.

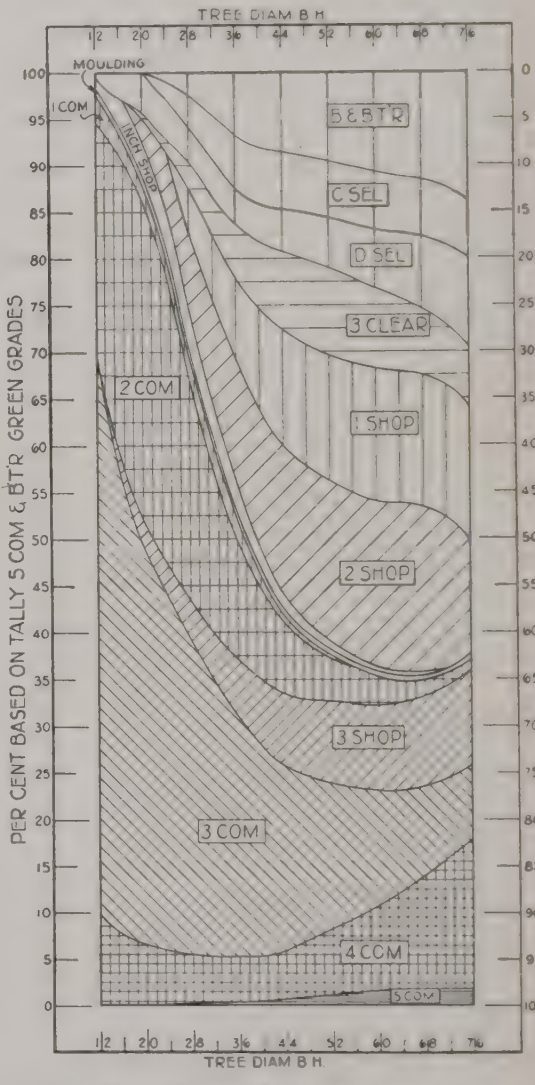


Fig. 17.—Green-lumber-grade production in ponderosa-pine trees.

Figures 16, 17, 18, and 19 show how green-lumber-grade production varied between the smallest and largest trees of each species on the study area. The space between top and bottom of the rectangular diagrams represents 100 per cent of the green-chain lumber production from average trees of the diameters noted on the scales above and below the rectangles. A vertical line extended through the diagram from any diameter will be divided into irregular intervals by the curved lines separating the various grades. Each of these intervals represents

the fractional percentage of the grade designated between the curved lines. The cumulative total percentage of all grades *below* any point where a vertical line crosses a curved line may be read directly by horizontal reference to the left-hand scale and that for all grades *above* such point, by reference to the right-hand scale.

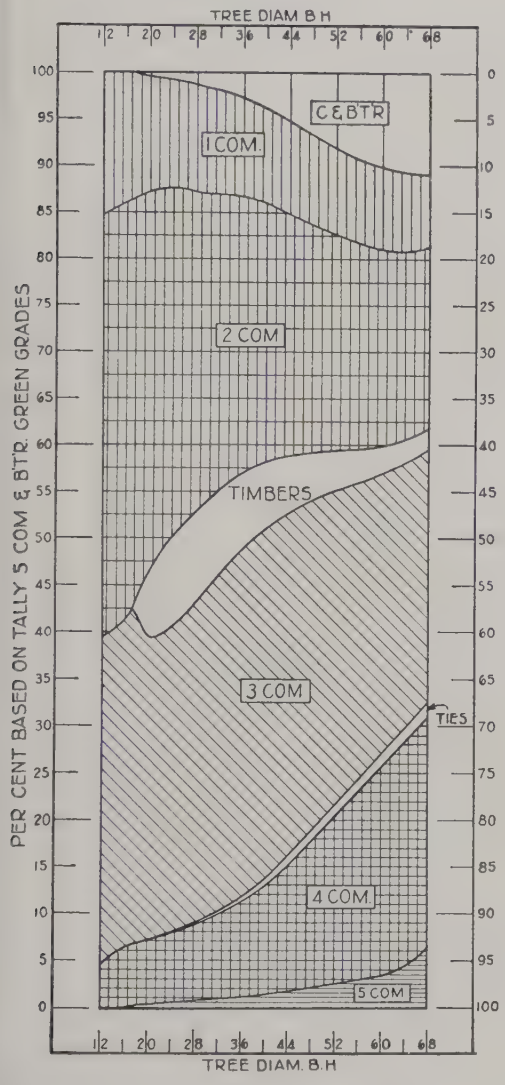


Fig. 18.—Green-lumber-grade production in white-fir trees.

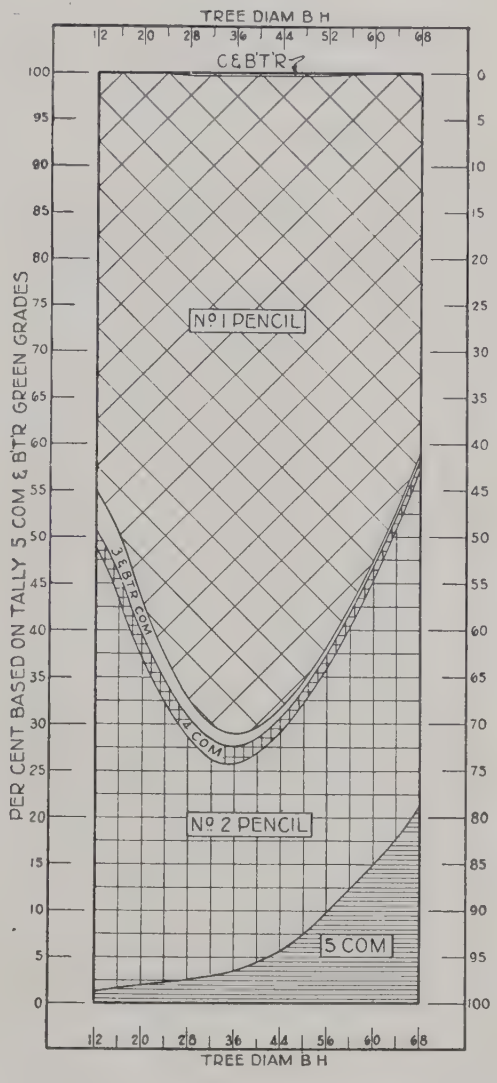


Fig. 19.—Green-lumber-grade production in incense-cedar trees.

Dotted lines have been extended vertically for 20-inch and 40-inch sugar-pine trees (fig. 16). Where these vertical dotted lines intersect some of the curved lines between lumber grades, horizontal dotted lines have also been extended to the left and right percentage scales, respectively. The letters in the small circles refer to these points of intersection. Sample readings, with reference to the designated points, are given below to illustrate how the approximate percentage of any particular grade or group of grades may be read from the figures for a given diameter of tree.

20-inch sugar-pine trees:

1,000 board feet of mill run lumber cut from this size is represente by vertical dotted line *A B C*.

All grades, Inch Shop to No. 5 Common, inclusive, = 100 per cent.

By reference to the left-hand scale:

A = 97 per cent of No. 2, No. 3, No. 4, and No. 5 Common, combine

B = 54 per cent of No. 3, No. 4, and No. 5 Common.

C = 10 per cent of No. 4 and No. 5 Common.

Deducting *B* from *A*: 97 – 54 = 43 per cent of No. 2 Common.

Deducting *C* from *B*: 54 –10 = 44 per cent of No. 3 Common.

If point *B* is projected by eye to the right-hand scale, the reading is 4 per cent from top of chart, meaning 46 per cent in the grades of No. Common and Better. Reading point *A* on the right-hand scale gives per cent in the grades of No. 1 Common, Inch Shop, and Molding con bined.

40-inch sugar-pine trees:

Line *D E F G H*, referred to right-hand scale:

D = 10 per cent of C Select and Better.

E = 15 per cent of D Select and Better.

E – *D* = 15 per cent – 10 per cent = 5 per cent of D Select alone.

F = 39 per cent of No. 2 Shop and Better.

F – *E* = 39 per cent –15 per cent = 24 per cent of No. 3 Clea No. 1 and No. 2 Shop, combined.

G = 53½ per cent of No. 2 Common and Better.

H = 91½ per cent of No. 3 Common and Better.

Reading point *H* from the left-hand scale shows approximately 9 pe cent of the lumber from 40-inch trees in the grades of No. 4 and No. Common combined—8½ per cent if the reading is taken more a curately.

Interpolation of exact values was not anticipated in constructing th diagrams, however. The object of combining the grades in this mann was, rather, to reduce detailed tabular data for each species to a con pact form enabling quick general comparisons between different siz of the same species and between different species as a whole.

In white fir (fig. 18), the grade of C and Better increased from le than 1 per cent in 20-inch trees to 11 per cent in 68-inch trees, but No. Common also increased from 6½ per cent to 20 per cent, and No. Common from 0.6 per cent to 6 per cent. Thus the increase in low-valu material tended constantly to counterbalance the increase in hig value material.

In incense cedar (fig. 19), 10/4 Pencil Stock was the principal product sought and the chart shows the results. There is an increasing amount of C and Better obtainable in the large trees but it is doubtful that any net gain would be made by sawing for it, as production costs would increase, while overrun and the percentage of No. 1 Pencil Stock would be reduced.

For sugar pine and ponderosa pine, the lumber-grade charts (figs. 16 and 17) show so clearly why selling values drop as diameters become smaller that any added comment would be superfluous.

Relation of Tree Diameter to Felling and Limbing Costs.—It is not enough to use merely the log margins as a guide in determining the size of the smallest tree which will just pay its way. To the cost of making the logs and converting them into lumber must be added the costs of felling and limbing—not a camp-average cost but the prorated cost for each size based on the time per M.B.M. spent by the fellers and limbers in chopping, sawing, wedging, and trimming any particular class of trees.

It took a very short time to fell and limb 12-inch trees and a long time to fell and limb 80-inch trees, but the time spent on the 80-inch tree produced 16,100 feet B.M. gross scale of saw logs, while that spent on the 12-inch tree produced but 50 feet B.M. In terms of dollars and cents, the felling and limbing of the 12-inch tree cost $0.53 and the 80-inch tree cost $8.76, including prorated bull buck's time, camp overhead, and tools. But, on an M.B.M. basis, felling and limbing 1 M.B.M. log scale from 12-inch trees cost $10.60 and the same volume from 80-inch trees cost $0.54. Relative costs for other sizes, on an M.B.M. mill-tally basis, are given in table 11.

Felling and limbing costs per M.B.M. mill tally for sugar pine *increased,* with decrease in tree diameter:

$0.05 from 60 to 50 inches
0.08 from 50 to 40 inches
0.18 from 40 to 30 inches
0.97 from 30 to 20 inches
$7.51 from 20 to 12 inches

Those operators who do felling and limbing by contract may be inclined to discount these increases because they are based on day-wage labor. Granting that contract labor will cut more timber in a day, there is, nevertheless, an inevitable decrease in output per man-hour as the trees cut become smaller, which amounts, in the last analysis, to the same thing as an increase in cost per M.B.M. The *rate* of increase, therefore, is significant.

This rate of increase per M.B.M. may be expressed in various way On a percentage basis, the increase in felling and limbing costs fo sugar-pine trees was 25.5 per cent with decrease in tree diameter fro 60 inches to 40 inches; from 40 inches to 20 inches, the increase was 18 per cent; and from 20 inches to 12 inches the increase was 420 per cen

TABLE 11

COST PER M.B.M. OF FELLING AND LIMBING SUGAR-PINE TREES

Tree diameter inches	Cost per tree	Mill-tally volume utilized, in feet B. M.	Cost per M. B. M. green-chain tally
12	$0.530	57	$9.30
14	0.541	90	6.01
16	0.549	145	3.79
18	0.574	224	2.56
20	0.590	329	1.79
22	0.627	457	1.37
24	0.678	613	1.11
26	0.747	781	0.96
28	0.829	960	0.86
30	0.929	1,130	0.82
40	1.674	2,634	0.64
50	2.772	4,950	0.56
60	$4.214	8,242	$0.51

The cost per M.B.M. mill tally for felling and limbing 18-inch suga pine trees in this study was four times as much, and for 12-inch trees was fourteen and a half times as much, as the cost of felling and limbi 40-inch trees.

Results for other species were similar to those for sugar pine. Actu costs for any diameter of any species may be read from the botto curves in figures 20, 21, 22, and 23.

Cumulative Costs for Trees.—With felling and limbing costs for ea species prorated to tree sizes, the next step is to add on all other cost except fixed acre expense, based on the log sizes in each d.b.h. class a arrive at the total costs per M.B.M. correlated with tree diameters.

The cumulative curves in figures 20, 21, 22, and 23 show how su combining of costs worked out for each species on the study area. T value curves in the same diagrams enable ready comparison betwe cost and value for any particular tree diameter. The only differen between the figures for logs (figs. 12–15) and those for trees (fig 20–23) is that felling and limbing costs are included in the latter a omitted from the former. A sample reading is given for the avera 28-inch sugar-pine tree in figure 20.

Cumulative costs for trees of different species and diameters are recapitulated in table 12. The amounts show the total expenditures per M.B.M. from felling to lumber-shipping inclusive. They do not include fixed-acre costs, slash disposal, or stumpage. The costs for each species are identical with those plotted for the same diameters in the "cumulative-cost" curves of figures 20 to 23.

TABLE 12

RELATIVE COSTS PER M.B.M.* FOR TREES OF DIFFERENT DIAMETERS

Tree diameter, inches	Sugar pine	Ponderosa pine	Sugar pine and ponderosa pine, average†	White fir	Incense cedar
14	$39.78	$37.57	$38.67	$31.94	$43.66
16	31.94	32.38	32.16	27.84	36.79
18	27.99	29.18	28.58	25.74	31.42
20	25.65	26.77	26.21	24.40	27.66
30	20.29	21.32	20.80	19.91	19.83
40	18.04	19.29	18.66	18.36	17.39
50	17.01	18.25	17.63	17.54	16.60
60	16.61	17.94	17.27	$17.55	$16.82
70	$16.59	$17.85	$17.22	.....	.....

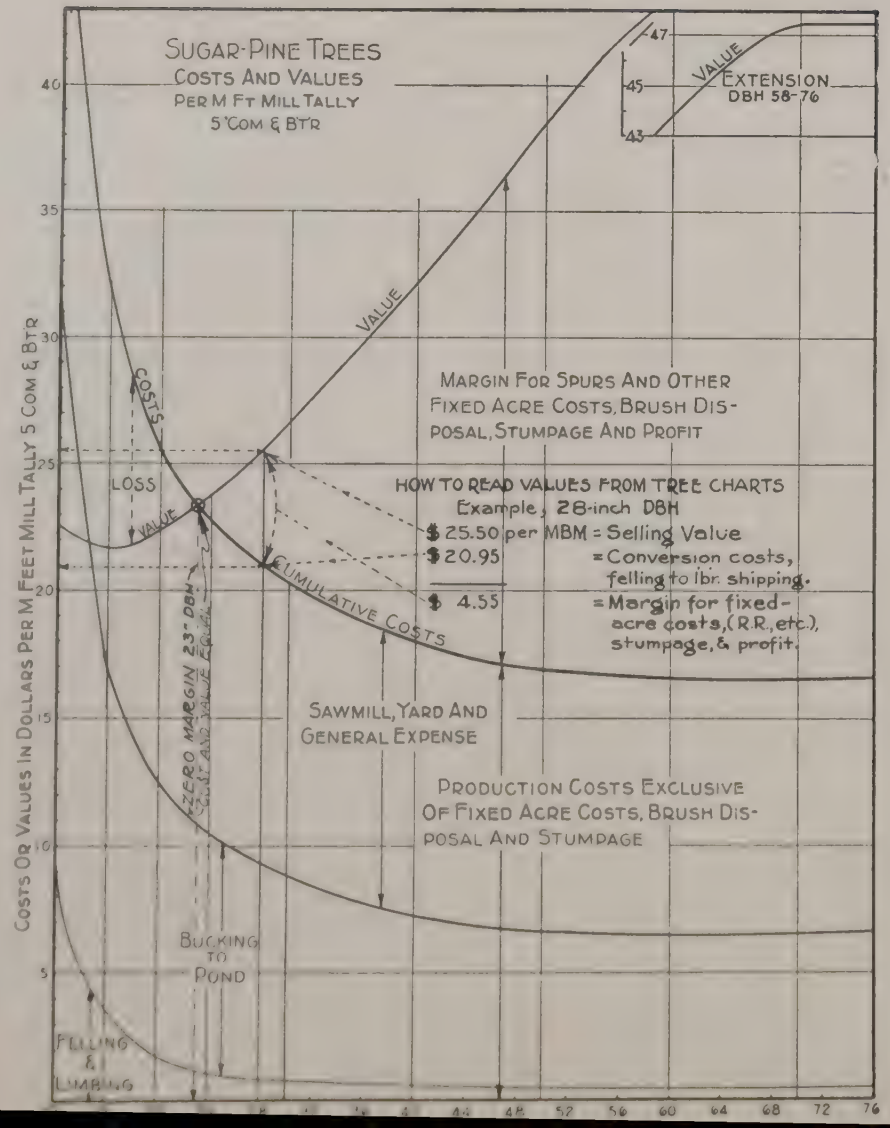
* Felling to lumber-shipping inclusive. Costs are on an M. B. M. mill-tally basis, No. 5 Common and Better.

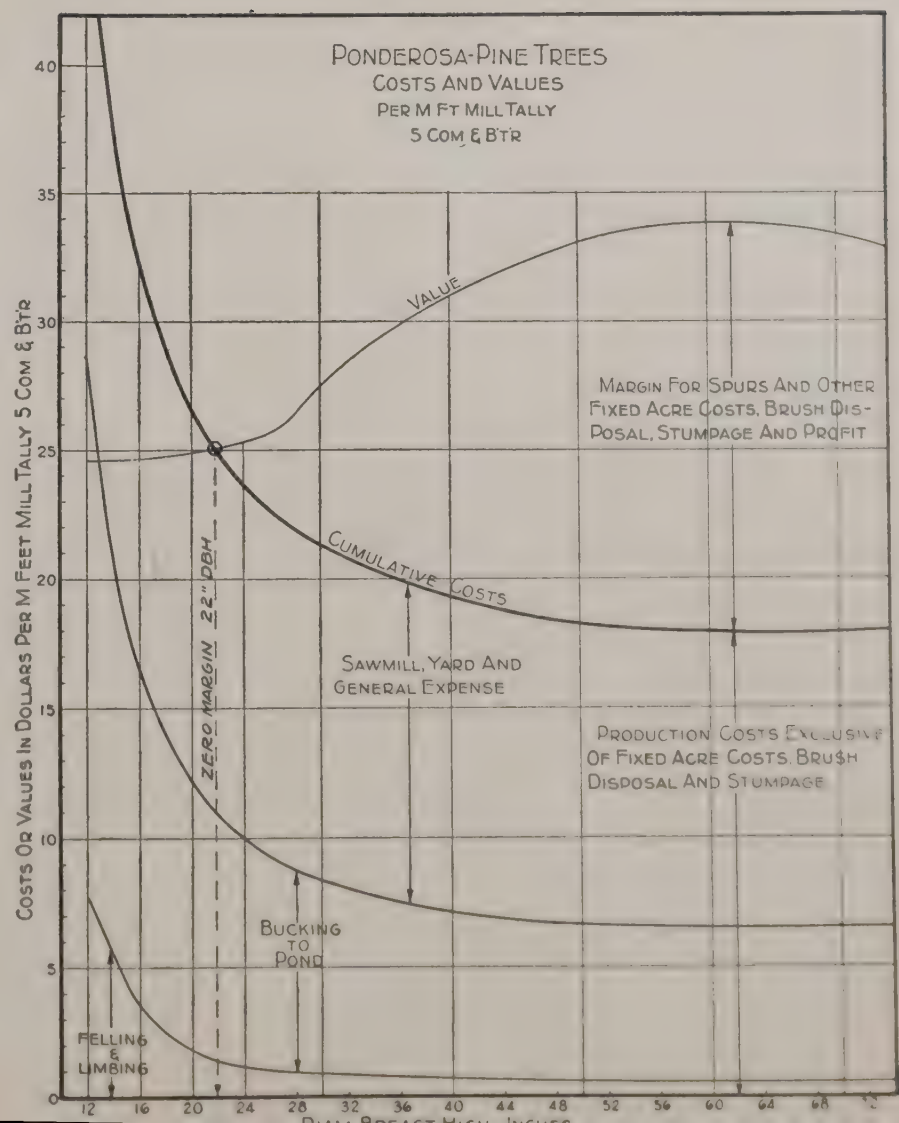
† Unweighted averages to compensate for fictitious differences in air-drying and kiln-drying costs and for probably exaggerated differences in small-tree costs because of the scarcity, and consequent inadequate sampling, of small ponderosa-pine trees on the study area.

A comparison of costs by tree diameter and species shows that cumulative costs per M.B.M. mill-tally for trees 20 inches in diameter and under were highest in incense cedar and lowest in white fir. For the larger sizes, incense-cedar costs were somewhat less than those for white fir and also less than average costs for the two pine species combined.

The average cumulative costs for sugar pine and ponderosa pine show that *lumber from 14-inch trees cost more than twice as much per M.B.M. to produce as lumber from 40-inch trees.* With decrease in tree diameter from 40 inches to 20 inches the increase in operating costs per M.B.M. was about 40 per cent, but from 40 inches to 14 inches, the increase was slightly more than 107 per cent.

Values per M.B.M. for Trees.—The curved values per M.B.M. for sugar-pine and ponderosa-pine trees (figs. 20 and 21) like those for logs, are discounted only for seasoning depreciation based on the rough-dry inspections of the summer-dried Shop and Better study lumber. Additional deductions for depreciation from surfacing, storage, and stain, and adjustment of seasoning cost differences must be made so that the values will be representative of average realizations obtained


SUGAR-PINE TREES
COSTS AND VALUES
PER M FT MILL TALLY
5 COM & BTR
47
45
43
VALUE
EXTENSION
DBH 58-76
VALUE
COSTS
LOSS
MARGIN FOR SPURS AND OTHER FIXED ACRE COSTS, BRUSH DISPOSAL, STUMPAGE AND PROFIT
HOW TO READ VALUES FROM TREE CHARTS
Example, 28-inch DBH
$25.50 per MBM = Selling Value
$20.95 = Conversion costs, felling to lbr. shipping.
$ 4.55 = Margin for fixed-acre costs, (R.R., etc.), stumpage, & profit.
CUMULATIVE COSTS
ZERO MARGIN 23" DBH
SAWMILL, YARD AND GENERAL EXPENSE
PRODUCTION COSTS EXCLUSIVE OF FIXED ACRE COSTS, BRUSH DISPOSAL AND STUMPAGE
BUCKING TO POND
FELLING & LIMBING
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY 5 COM & BTR
40
35
30
25
20
15
10
5
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76


PONDEROSA-PINE TREES
COSTS AND VALUES
PER M FT MILL TALLY
5 COM & BTR
VALUE
MARGIN FOR SPURS AND OTHER FIXED ACRE COSTS, BRUSH DISPOSAL, STUMPAGE AND PROFIT
CUMULATIVE COSTS
ZERO MARGIN 22" DBH
SAWMILL, YARD AND GENERAL EXPENSE
PRODUCTION COSTS EXCLUSIVE OF FIXED ACRE COSTS, BRUSH DISPOSAL AND STUMPAGE
BUCKING TO POND
FELLING & LIMBING
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY 5 COM & BTR
40
35
30
25
20
15
10
5
0
12
16
20
24
28
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40
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52
56
60
64
68

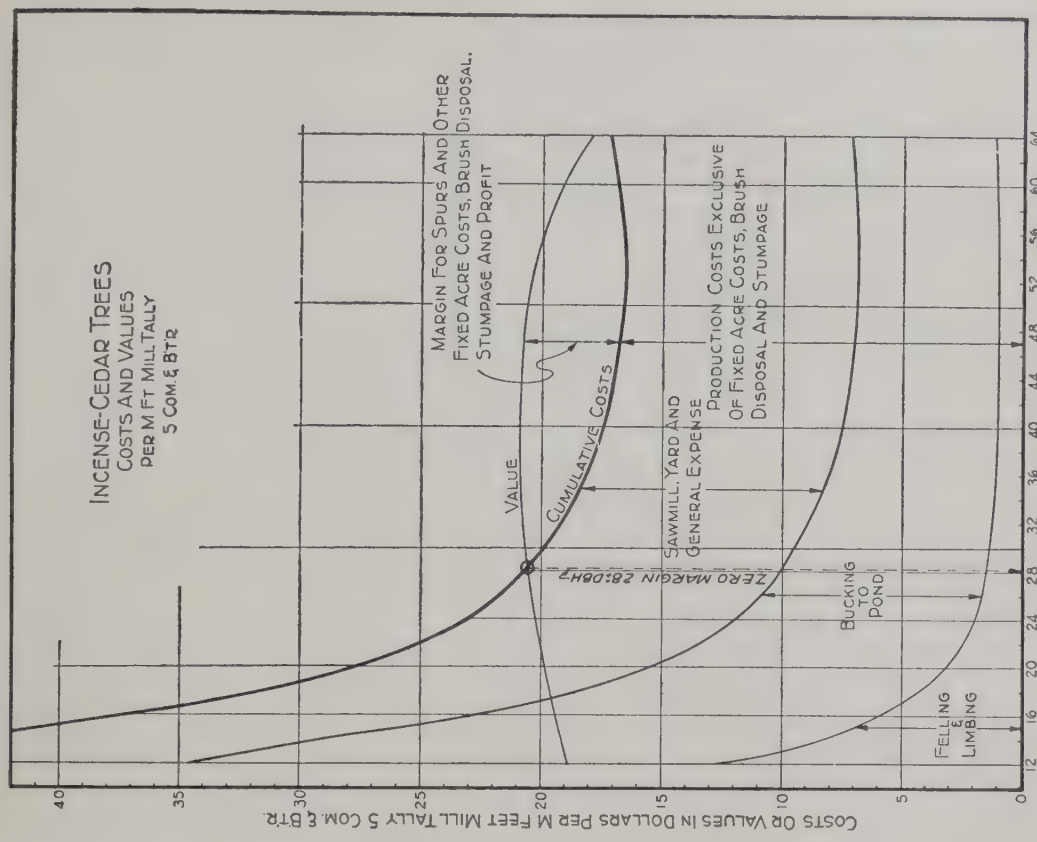

INCENSE-CEDAR TREES
COSTS AND VALUES
PER M FT MILL TALLY
5 COM. & BTR.
MARGIN FOR SPURS AND OTHER FIXED ACRE COSTS, BRUSH DISPOSAL, STUMPAGE AND PROFIT
VALUE
CUMULATIVE COSTS
SAWMILL, YARD AND GENERAL EXPENSE
PRODUCTION COSTS EXCLUSIVE OF FIXED ACRE COSTS, BRUSH DISPOSAL AND STUMPAGE
ZERO MARGIN 28" DBH
BUCKING TO POND
FELLING & LIMBING
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY 5 COM. & BTR.
DIAM BREAST HIGH-INCHES

Fig. 23

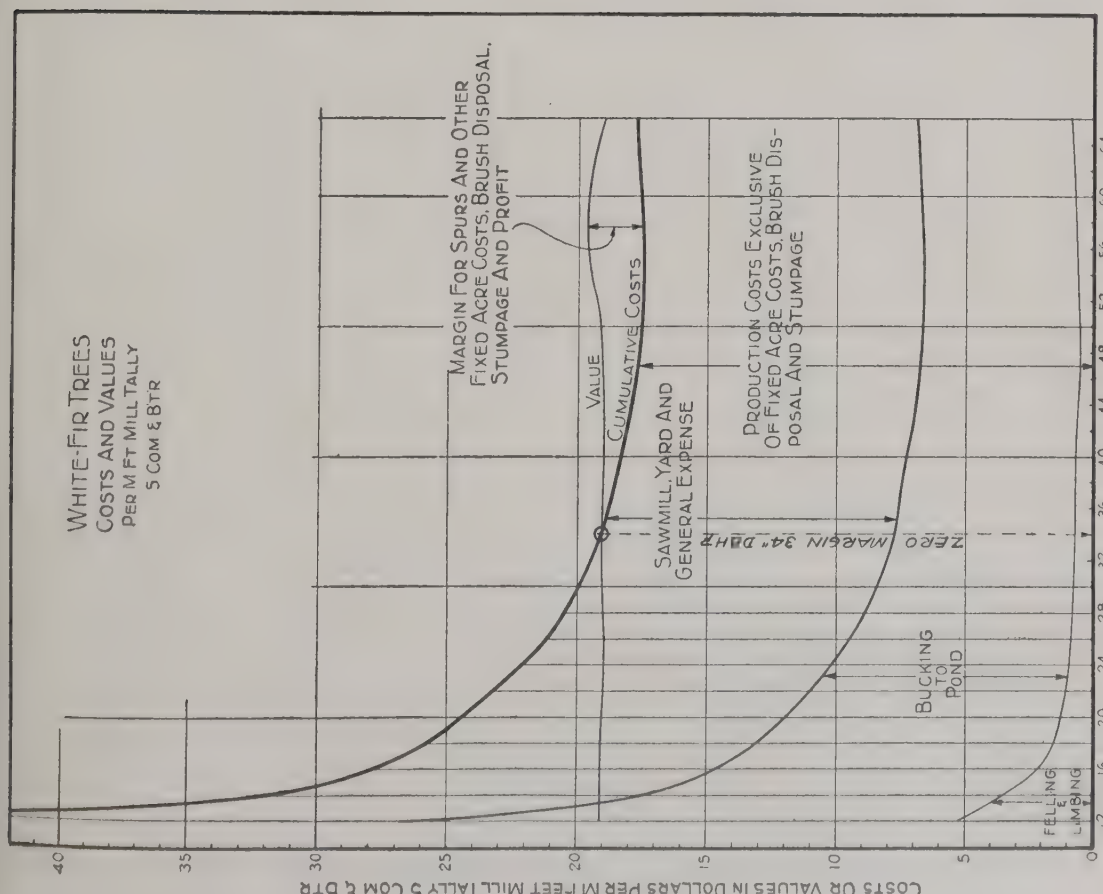

WHITE-FIR TREES
COSTS AND VALUES
PER M FT MILL TALLY
5 COM & BTR
MARGIN FOR SPURS AND OTHER FIXED ACRE COSTS, BRUSH DISPOSAL, STUMPAGE AND PROFIT
VALUE
CUMULATIVE COSTS
SAWMILL, YARD AND GENERAL EXPENSE
PRODUCTION COSTS EXCLUSIVE OF FIXED ACRE COSTS, BRUSH DISPOSAL AND STUMPAGE
ZERO MARGIN 34" DBH
BUCKING TO POND
FELLING & LIMBING
COSTS OR VALUES IN DOLLARS PER M FEET MILL TALLY 5 COM & BTR
DIAM BREAST HIGH-INCHES

Fig. 22

over a period of one or more seasons.[16] These affect principally the large trees from which the Selects and upper Shop grades are cut. The correc tions for tree values appear in table 13.

TABLE 13

DEDUCTIONS PER M.B.M. FOR SURFACING, STAIN, AND STORAGE DEGRADE* TO BE TAKEN FROM CURVED VALUES FOR SUGAR-PINE AND PONDEROSA-PINE TREES

Tree diameter, inches	Sugar pine	Ponderosa pine
20	$0.00	$0.00
22	0.00	0.10
24	0.00	0.38
26	0.35	0.53
28	0.66	0.70
30	1.00	0.83
40	1.97	1.39
50	2.52	1.60
60	3.03	1.80
70	3.40	$2.06
80	$3.45	.....

* Including adjustments of comparative seasoning costs.

The following list of final average selling rices per M.B.M. for lumbe from a few selected sizes of sugar-pine and ponderosa-pine trees show the enhancement in values with increase in tree diameter from 14 inche to 60 inches after making the corrections given in table 13.

TREE DIAMETER, INCHES	SUGAR PINE	PONDEROSA PINE
14	$21.93	$24.53
30	25.58	26.59
40	30.18	29.54
60	40.76	31.98

From these results, it is evident that lumber from 14-inch sugar-pin trees was worth 46 per cent less, per M.B.M., than lumber from 60-inc trees, and 27 per cent less than lumber from 40-inch trees. Lumber fro 14-inch ponderosa-pine trees was worth 23 per cent less, per M.B.M. than lumber from 60-inch trees, and 17 per cent less than lumber fro 40-inch trees.

There was little change in the M.B.M. value of white-fir trees of diffe ent diameters, the reason for which has been explained under "Relatio

[16] See "Additional Depreciation of Pine Species" and "Adjustment of Sugar Pine Seasoning Costs," pages 25 and 27, for explanation of these correction factors

of Tree Diameter to Lumber Grades Produced," page 41. Incense-cedar lumber declined in value with increase in tree diameter above 50 inches somewhat more sharply than with decrease in tree diameter below 30 inches. The ravages of incense-cedar dry rot, entering mostly through fire scars on the butts of trees and increasing rapidly with increasing age, were responsible for the reversion. Between 30-inch and 50-inch diameters, the mill-run values were very nearly the same.

Zero-Margin Diameters for Trees.—The diameters breast high, measured outside the bark, of trees which just paid back the costs from felling to lumber shipping, with nothing left from the selling value to pay for stumpage or fixed acre expense, were:

Sugar pine	23 inches
Ponderosa pine	22 inches
White fir	34 inches
Incense cedar	28 inches

These are the zero-margin tree diameters designated in figures 20 to 23 by the dotted lines extended to the lower scales from the points of intersection of the "cumulative cost" curves with the "value" curves. To the left of these points, the cost curves rise very rapidly. The losses per M.B.M. incurred on lumber from trees below the zero-margin diameters may be derived approximately from the left-hand dollar scales by deducting the scale reading for "value" from the scale reading for "cumulative cost" directly above any given diameter on the lower scale.

Tree Margins.—The margins for white fir and incense cedar left from selling values after costs from felling to lumber shipping have been deducted may be read for any tree size from figures 22 and 23. No corrections are necessary for further depreciation.

The maximum average margin for white fir was $2.17 per M.B.M. on lumber from 56-inch trees. In 40-inch trees the margin was $0.69. There was a loss of $8.76 per M.B.M. on the lumber from 16-inch trees, and a loss of $12.84 on 14-inch trees.

Incense cedar was somewhat better in the middle sizes, with a maximum margin of $4.08 per M.B.M. on lumber from 48-inch trees. Going up the diameter scale, the margin fell to $0.73 on 64-inch trees, owing to cull. Down the scale, the margin on 40-inch trees was $3.51, and in 30-inch trees, $0.81 per M.B.M. The loss on 16-inch trees was $17.38, and on 14-inch trees the loss jumped to $24.47. The very small volumes in incense-cedar trees below 20 inches d.b.h. accounts for the fact that losses in the smallest sizes are so much greater than the losses on corresponding sizes in the white fir.

The pine margins, after adjusting in accordance with table 13, differ by varying amounts from the chart margins. Table 14 lists the corrected values for different d.b.h. classes.

TABLE 14

CORRECTED MARGINS* PER M.B.M. FOR SUGAR-PINE AND PONDEROSA-PINE TREES

Tree diameter, inches	Sugar pine	Ponderosa pine
14	—$17.85†	—$13.04†
16	—10.33†	— 7.78†
18	— 6.19†	— 4.48†
20	— 3.25†	— 1.96†
24	1.05	1.23
30	5.29	5.27
40	12.14	10.25
50	18.97	13.19
60	24.15	14.04
70	27.41	$13.49
80	$27.34	.....

* Margins per M. B. M. mill tally No. 5 Common and Better obtained by deducting "cumulative costs," as shown in figures 20 and 21, from tree values in same figures and then reducing these further by the amounts given in table 13. The margins in this table, therefore, are corrected for all types of lumber depreciation and incorporate seasoning-cost adjustments.

† Minus sign indicates operating loss.

It is evident from figures 20 to 23, that the margins of both pine species go far above the white-fir and incense-cedar margins in the larger tree sizes, but it is also evident (table 14) that *these high margins in the large pine trees are very rapidly reduced as tree sizes become smaller*. Increasing costs and decreasing values per M.B.M. combined to change a ponderosa-pine value which was 53.1 per cent above costs for 40-inch trees to a loss of 7.3 per cent on 20-inch trees, and a loss of 34.7 per cent on 14-inch trees. A similar combination changed a sugar-pine value which was 67.3 per cent above costs for 40-inch trees to a loss of 12.7 per cent on 20-inch trees and a loss of 44.9 per cent on 14-inch trees.

CUTTING TO DIFFERENT MINIMUM TREE-DIAMETER LIMITS

Cutting to fixed tree-diameter limits irrespective of individual tree characteristics is not to be unqualifiedly recommended from either a forestry or a current-maximum-profit standpoint, although it is obvious that a minimum limit of 24 or 26 inches, for example, would leave west slope cut-over lands in far better condition than the present 12 to 16-inch limits, and it is certain that operators would be rewarded by an immediate enhancement of net income. But no single tree-variable in a virgin

forest of mixed size-classes and mixed species can be isolated as an absolute index of relative future or present value. An operator managing his property as a permanent, sustained-yield unit will want to make the utmost from his capital investment in forest land. Stand improvement will be an objective of the cutting system adopted, as well as profitable current realization. His cutting instructions, therefore, should call for a certain degree of tree selection based on disease, deformity, insect infestation, stagnation due to overcrowding in heavily stocked groups, and other factors aside from tree size alone. Even if cutting exclusively for current profit with the idea of full liquidation and cessation of operation when all available virgin acreage has been cut over the first time, the operator-owner should recognize the desirability of some deviation above and below any *average* limits established by analysis of his own timber. The frequency of visible knots on the lower 16 to 24 feet of the bole is perhaps the most reliable index as a guide in judging whether a tree 2 or 3 inches larger than the average economic diameter limit should be left or whether a tree 2 or 3 inches smaller than the average economic limit can be profitably utilized.

But regardless of the short comings of mere diameter-limit cutting, an analysis of its effect on average costs, when fixed-acre expense is included in the total, is essential as a final revelation of the true significance of tree size in the west-slope lumbering operation studied.

In appraising the marginal value of a *log* after the tree is cut, limbed, and ready for bucking, only the costs incurred from that point on are deducted from the ultimate selling value of the log. In appraising the marginal value of a *tree* after railroads, camps, landings, etc., are installed, all log-conversion expense to be incurred by the logs in the tree, *plus* the felling and limbing costs, are deducted from the ultimate selling value of the tree. The tree must pay back all of these costs before anything can be contributed toward fixed acre expense. In appraising the average marginal value of a *woods-run mixture of trees of different species and sizes,* all of the tree and log costs, *plus* the fixed acre expense must be deducted from the average selling value of the mixture.

As a matter of efficient logging-operation planning, the costs treated as fixed costs per acre in this bulletin *should* vary per acre with the percentage of the stand cut. A heavy yield per unit of area calls for more railroad and shorter yarding distances. A light cut may come to the mill more economically with less railroad and longer yarding distances. They are left as a constant herein, however, both for simplification in presenting the comparative results of different cutting-diameter limits and for emphasizing the fact that even when a large expenditure is made for

railroad spurs, the operator can still reduce his average total costs pe
M.B.M. by leaving many small trees standing which he now thinks
profitable to bring in.

Figure 24 follows through, for each of seven different minimum tre
diameter cutting limits: (1) the volume in M.B.M. net scale cut pe
acre; (2) the number of trees between 12 inches d.b.h. and the minimu
diameter limit which would be left per acre, without deductions fo
felling and logging losses[17]; (3) the fixed acre cost of $84.64 for rai
roads, camps, etc., spread over the net scale utilized when cutting t
each limit; (4) the average conversion costs per M.B.M. net scale, whic
include all other costs except fixed acre expense; (5) the combined tota
costs per M.B.M. net scale, which are the sum of the fixed acre and co
version costs for each cutting limit; (6) the average selling value pe
M.B.M. net scale, discounted for lumber depreciation; (7) the averag
margin per M.B.M. net scale, obtained by deducting combined cost
from selling values; and (8) the margin per acre, obtained by multiply
ing the average margin per M.B.M. net scale by the M.B.M. cut per acr

As shown by the data and bar-diagrams in figure 24, cutting every
thing on the study plots to 12 inches d.b.h., inclusive, gives a yield o
53.2 M.B.M. net scale per acre. If 31 trees per acre from 12 to 35 inche
d.b.h. are *not* cut, the yield will drop to 38.9 M.B.M.

The fixed acre cost of $84.64 must be charged off against whateve
is cut, therefore it increases, on an M.B.M. basis, from $1.59 for th
12-inch limit to $2.18 for the 36-inch limit. But this is the only co
which does increase. Also the increase is small considering the bi
change in minimum cutting limit—it goes up only $0.59 per M.B.M
equivalent to an average increase of but 2½ cents for each inch of diffe
ence, between the 12 and 36-inch limits.

The much larger share of total production costs, designated as co
version costs per M.B.M. in the chart, steadily decreases as more an
more of the smaller, high-cost trees are left uncut, i.e., high-cost in re
spect to felling, limbing, bucking, yarding, loading, log transportatio
decking, and sawing. Costs for plant overhead, selling, shipping, etc
are included in the conversion costs but these have been treated in th
report as fixed costs per M.B.M. The decrease in the average conversio
cost, felling to lumber shipping, is $1.45 per M.B.M. when the cuttin
limit is raised from 12 inches to 36 inches d.b.h., which not only offse

[17] The heavier the cut, the greater is the percentage of loss in the small-tree pop
lation left. With the 16-inch limit, the 10 trees per acre not cut, from 12 to 15 inch
d.b.h. inclusive, as shown in figure 24, would be reduced by at least 50 per ce
owing to breaking off by other trees in falling and to damage from yarding.

the $0.59 increase in fixed acre costs, but also gives an additional saving of $0.86 per M.B.M.

Midway between the 12 and 36-inch limits, cutting to a *24-inch limit* increases fixed acre costs by 12 cents per M.B.M. and decreases other costs by 85 cents per M.B.M., a net saving of 73 cents.

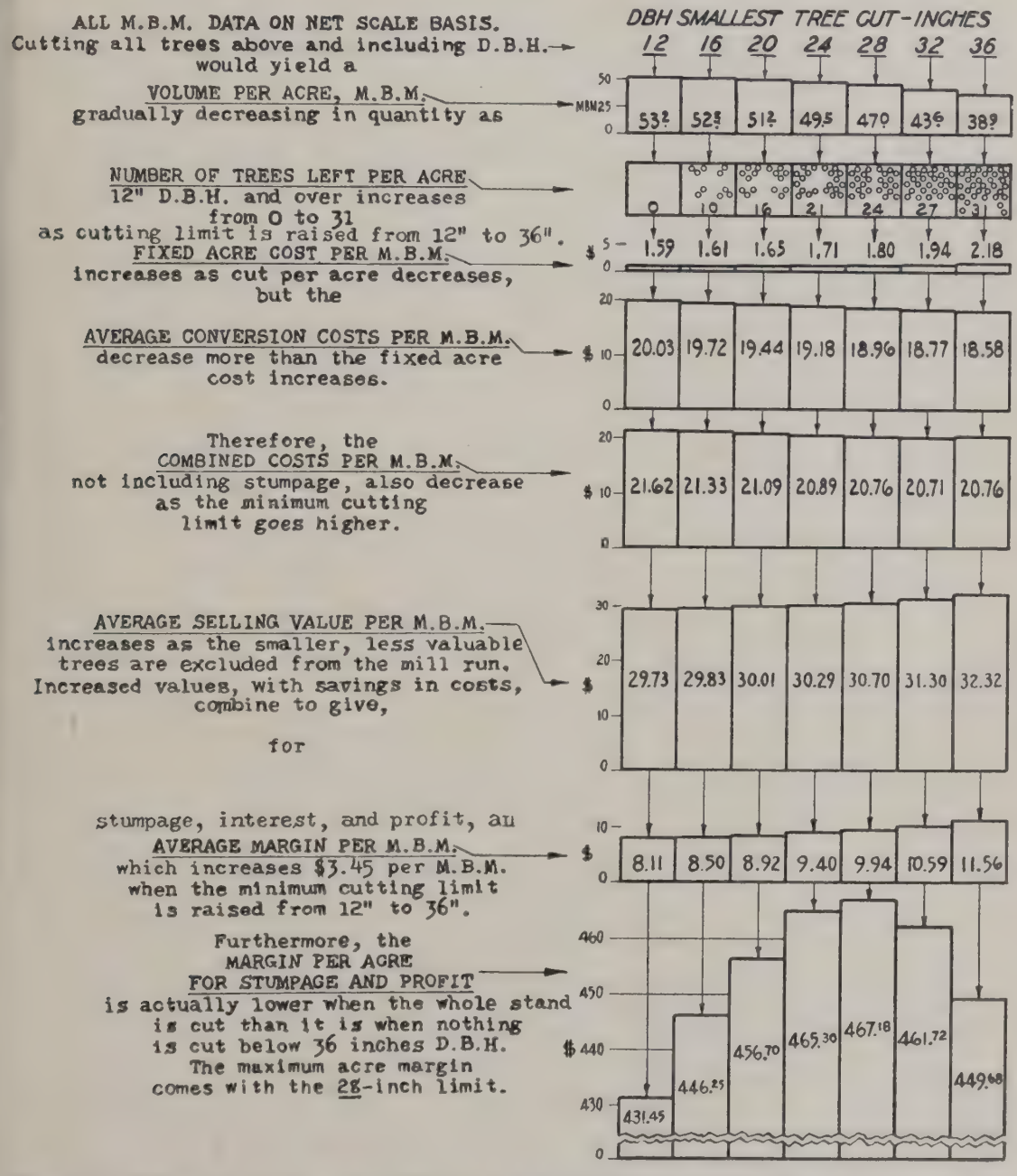


Fig. 24.—Effect of cutting to different d.b.h. limits on the Stanislaus study area.

The greatest saving in combined costs per M.B.M. comes with the 32-inch limit, which gives a net reduction of 91 cents per M.B.M. under the clear cutting (12-inch limit) costs.

The average selling value per M.B.M. net scale with the 36-inch limit increases $2.59 over the average of $29.73 yielded by 1 M.B.M. of mill-

run lumber from clear cutting. The increase would not be so large if the stand were pure ponderosa pine but it would be larger if the stand were pure sugar pine. Mixture of species in varying proportions for different diameter-breast-high classes unavoidably has an influence on average selling prices aside from the effect of change in cutting diameter limits.

Combining the savings in total operating costs with the rise in average value of the mill-run product, the average margin per M.B.M. jumps from $8.11 (12-inch limit) to $11.56 (36-inch limit). This is an increase of $3.45 in the margin per M.B.M. available for stumpage and profit.

The comparative heights of the bars at the bottom of figure 24 demonstrate conclusively the false economy of cutting to the customary 16-inch d.b.h. limit in virgin stands of the type studied. From the standpoint of profit per M.B.M. on the season's cut, there is a reduction in the average mill-run margin of $3.06 per M.B.M. from cutting 21 additional trees per acre in tree diameters below 36 inches and above 15 inches. *From the standpoint of profit per acre, there is a reduction of $20.93 in acre-margin from cutting 14 trees per acre below 28 inches and above 15 inches d.b.h.*

APPLICATION OF RESULTS TO OTHER OPERATIONS

Readers of this report may feel that it should close with recommendations for specific cutting systems. Unfortunately that cannot be done intelligently for a region or a subregion, since the cutting system best adapted to the needs of operator A may not be suitable for operator B. Just what trees to cut and what trees to leave depend on the operator's objectives, the size of the timber holdings he controls, the methods of logging used, the size of his mill, his market, and a dozen or more other factors concerning his own particular stand and his own local conditions.

But omission of details concerning what should and what should not be cut to comply with various objectives of management need not cause any operator in the west-slope region to hesitate about accepting the evidence herein given concerning the losses on small trees. Their low selling values come from the low lumber grades produced. These low grades result from their characteristic growth habit—full crowned, with green limbs still growing to the butt log and few to many dead limbs protruding through the bark all the way to the stump. The small trees on the study plot were typical of all small trees in the region, therefore their values are undoubtedly representative of small-tree values throughout the region.

Costs are also typical of the region for the type of logging studied. Regional averages were actually used for many items, and for those items necessarily based on the cooperating company's wage scales and expenditures for materials, the company averages were practically identical with regional averages. The item subject to greatest variation as between different operations is probably the fixed acre cost, but it should be remembered that this has no bearing on the zero-margin tree as defined in this report. The loss of $1.96 per M.B.M. on 20-inch ponderosa-pine trees and the loss of $3.25 per M.B.M. on 20-inch sugar-pine trees, shown in table 14, likewise were derived from calculations into which fixed acre costs did not enter.

Naturally, the cost per M.B.M. of producing lumber will vary with differences in wage scales, costs of material and supplies, etc., and the gross income will vary with differences in lumber selling prices. The low selling values of 1932 if applied in this study, would give lower tree values all along the line. Lower average costs would mean lower costs per M.B.M. for each tree size. If every lumber grade dropped exactly 40 per cent in value and every item of cost dropped exactly 40 per cent, the margins for fixed acre costs, stumpage, and profit shown in figures 20 to 23 would all be less for those diameters where values are greater than conversion costs, and by the same token the actual cash losses would be less for those diameters where values are less than conversion costs, but the zero-margin diameters would remain precisely where they are. On the other hand, if costs were decreased 30 per cent and the values of trees near the present zero-margin sizes dropped 35 per cent, the zero-margin diameters would be larger than those shown. For sugar pine, for example, such a combination would result in raising the zero-margin diameter from 23 inches to about 24½ inches. If the situation were to be reversed, with reduction in costs exceeding decline in value of the 1928–1930 zero-margin size, the latter would move down the scale. But so far, values have dropped by a greater percentage than production costs, so that the line of demarcation between the profitable and the unprofitable, i.e., the zero-margin limit, has shifted upward since the computations were made for this report.

It is true, of course, that margins on the same sizes of pines in other parts of the west-slope region and in the same type of timber may be more or less than those obtained in this study even under the same general schedule of prices, wages, and material charges, owing to differences in methods, equipment used, length of haul to mill, and so on. It is practically certain, however, that *every operation designed to handle and saw the big virgin timber found on the better areas of the western*

Sierra slopes is losing money on many of the smaller sizes of trees now being cut from private lands. It will be of very real economic benefit to such operators to raise their minimum cutting diameter limits for the pines considerably above the present 12 to 16-inch limits. That there would also be a tremendous improvement in the condition of private cut-over lands resulting from the widespread adoption of such changed practice is, of course, self-evident. But entirely apart from any forestry considerations whatever, *the leaving of small trees which do not pay their way is a practice which should be universally adopted by lumbermen purely on its merits as an operating economy.*

SUMMARY

A coordinated logging and milling study involving a typical virgin stand of Site-1, west-slope, California-pine-region timber, direct-tractor skidding, a 36-mile, standard-gauge-railroad log haul, and a double-band sawmill cutting about 80,000 M.B.M. per annum, was conducted in such a manner that costs and values could be determined separately for each species, size, and grade of logs and for each species and size of trees.

The stand studied contained a mixture of sugar-pine, ponderosa-pine, white-fir, and incense-cedar trees of all ages and sizes. The smallest tree of each species analyzed as to costs and value was 12 inches d.b.h. The largest was an 80-inch sugar pine. Maximum sizes of the other three species were: white fir and incense cedar, 64 inches d.b.h., ponderosa pine, 76 inches d.b.h. By volume, the original gross stand of approximately 59 M.B.M. per acre was made up of about 35 per cent white fir, 34 per cent sugar pine, 20 per cent ponderosa pine, and 11 per cent incense cedar.

The costs per M.B.M. of felling, limbing, bucking, yarding, loading, decking, unloading, and sawing increased as tree diameters decreased, the cumulative effect of these increases becoming so pronounced in the smallest d.b.h. classes that the total of all costs, variable and nonvariable, from felling to lumber shipping, inclusive, was approximately twice as much per M.B.M. for lumber from 14-inch trees as for lumber from 40-inch trees. Concurrently, values per M.B.M. decreased as tree diameters became smaller, the percentage of decrease being greatest in the pine species.

In all species, lumber from 40-inch trees was worth more than its production costs (excluding fixed-acre charges and stumpage) but lumber from average white-fir trees below 34 inches, average incense-cedar trees below 28 inches, average sugar-pine trees below 23 inches, and average

ponderosa-pine trees below 22 inches in breast-high diameter, was worth *less* than production costs. Average trees of the diameters noted yielded lumber of a value just sufficient to balance all costs except stumpage and fixed-acre charges. There being no margin for profit in utilizing trees of these sizes, they are termed the zero-margin diameters. The rate at which losses per M.B.M. increased below these diameters is indicated by the excesses of costs over values for 14-inch trees of each species. Based on average lumber selling prices and average costs for the period 1928–1930, inclusive, the *losses* per M.B.M. on lumber from average 14-inch trees were as follows: sugar pine, $10.33; ponderosa pine, $7.78; white fir, $12.84; incense cedar, $24.47.

For the stand as a whole, the maximum margin per acre would come, of course, from cutting every tree with a value equal to or greater than the felling-to-lumber-shipping costs, i.e., to the minimum zero-margin sizes given above. Disregarding species differences, the average minimum tree-diameter cutting limit to give the greatest margin per acre was 28 inches. Maximum margin per acre, however, is not analogous to maximum profit per M.B.M., or maximum profit on a season's cut. For a greater margin of profit on the investment and working capital, the minimum sizes of trees to be cut will usually be well above the zero-margin diameters on any area. For the stand studied, a minimum average cutting limit of 36 inches d.b.h. gave a net margin for stumpage, interest, and profit which was $1.62 per M.B.M. higher than the margin per M.B.M. obtained by cutting to the 28-inch average limit (i.e., for maximum margin per acre).

Just what cutting system will be best for a particular operator can only be determined from an analysis of the particular stand, the local situation, and the particular objectives of management. The results presented in this bulletin, however, may be regarded as reliable indicators of the approximate average tree diameters in the better Site-1 virgin stands of the west-slope region below which conversion costs become greater than the values recoverable. A small percentage of such submarginal trees should occasionally be cut for silvicultural reasons, but to cut them merely for increased volume per acre to reduce railroad construction costs per M.B.M. is wholly unjustified. This limit was above 20 inches d.b.h. on the study area even in the most valuable pine species. The larger operators in the west-slope pine region will find it good economy to raise their present minimum pine-tree diameter cutting limits from 12–16 inches to at least 22–24 inches. Still greater gains from the economic standpoint will be possible by raising the limit above 24 inches.

ACKNOWLEDGMENTS

Acknowledgment is made to the Pickering Lumber Company for their cooperation in the conduct of the field studies, which were in continuous progress from May, when the felling observations began, to December, 1929, when the last seasoning-study lumber piles were inspected for depreciation.

When the yarding, loading, and sawmill studies were in full swing, some 35 men were required for study-crew duty (including day and night shifts in the mill). For the services of those individuals on the various crews who were not employed directly by the California Forest Experiment Station or the Division of Forestry of the University of California, the latter are indebted to the Region-5 Office of Forest Management, the Region-1 Office of Forest Products, the Stanislaus National Forest, the Sierra National Forest, and the Tahoe National Forest, of the Forest Service, United States Department of Agriculture; also the California White and Sugar Pine Manufacturers' Association (now merged with the Western Pine Association), and the cooperating lumber company mentioned above.

Although the results of their special studies are not included in this bulletin, cooperation of the following bureaus of the United States Department of Agriculture should also be acknowledged, viz., the San Francisco Office of Forest Pathology, Bureau of Plant Industry, and the Berkeley Office of Forest Insect Investigation, Bureau of Entomology. Summaries of their findings will appear in the proposed publication referred to in the footnote on page 10.

Many of the data collected were subjected to analysis from several different angles in order to work out the most satisfactory and reliable methods of computing and coordinating the numerous variables encountered. For this work, special credit is given to Ira J. Mason and Burnett Sanford, of the California Forest Experiment Station.

A share of the expense of the office work on the project was borne by the Sugar Pine Lumber Company, the Michigan-California Lumber Company, the Fruit Growers Supply Company, the Clover Valley Lumber Company, and the California Forest Protective Association.

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The Classification and Evaluation of the Soils of Western San Diego County

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The Classification and Evaluation of the Soils of Western San Diego County[1]

R. EARL STORIE[2]

INTRODUCTION

During 1929 and 1930 detailed soil surveys covering the western half of San Diego County were made and are now being prepared for publication in three reports under the names of the Oceanside, Capistrano, and El Cajon areas.[3] These areas are shown on the sketch map (fig. 1). The Capistrano Area covers those portions of Orange and San Diego counties lying south of Township 6 South and west of the Riverside County line, while the south boundary coincides with the south boundary of the Santa Margarita Rancho. The Oceanside Area lies to the south and covers the territory from the coast east into the mountains beyond Pala, Pasqual, and Poway valleys, and south to the north line of Township 15. The El Cajon Area extends south to the international boundary and east well into the mountains beyond Lyons Valley. Together these surveys cover all the western half of San Diego County and include most of the agricultural lands.

A reconnoissance soil survey[4] covering most of San Diego County was made during the winter of 1915 as one of six such surveys that covered the major portions of southern California, the Sacramento and San Joaquin valleys, and the San Francisco Bay Region. These were generalized surveys with maps made on the scale of 2 miles to the inch (the scale of the Sacramento Valley map is 4 miles to the inch) showing the

[1] Received for publication September 13, 1932.

[2] Assistant Soil Technologist in the Experiment Station.

[3] Cooperative work between the Division of Soil Technology of the University of California and the United States Department of Agriculture Bureau of Chemistry and Soils:

Storie, R. Earl, and E. J. Carpenter. Soil Survey of the Oceanside Area, California. (In press.)

Carpenter, E. J., and R. Earl Storie. Soil Survey of the Capistrano Area, California. (In preparation.)

Storie, R. Earl, and E. J. Carpenter. Soil Survey of the El Cajon Area, California. (In preparation.)

[4] Holmes, L. C., and R. L. Pendleton. Reconnoissance soil survey of the San Diego Region, California. U. S. Dept. Agr. Bur. Soils, Field Operations 1915, Report 64:2509–2581. 1919.

soils in rather inclusive groupings of types within a series, or even in some cases of undifferentiated series. Individual soil types were shown wherever of sufficient extent to be accurately separated out and shown



Fig. 1.—Sketch map of the western portion of San Diego County and southwestern Orange County, showing location of various soil groups, and the area covered in each of the detailed areas (Capistrano, Oceanside, and El Cajon).

R, Mountainous, stony, or broken land (includes isolated areas of group I soils).

I, Soils of group I.

Ic, Heavy-textured soils of subgroups I*b* and I*c* occurring on the coastal plain and derived from calcareous parent material.

II, Soils of group II, with inclusions of group III soils.

III, Light-textured soils from marine-terrace materials (Elkhorn and Marina series).

IV, Semimaturely and maturely weathered coastal plain soils of group IV.

on the map, but in most cases related types were combined in the reconnoissance surveys. These reconnoissance surveys have served as a guide to the general soil conditions in the several regions, but are being sup-

planted as rapidly as facilities permit by detailed soil surveys made on the much larger scale of 1 mile to the inch on the map. These detailed surveys show occurrences of soils in areas as small as 10 acres or less, while the reconnoissance surveys rarely show bodies of soil of less area than 160 acres. The detailed maps are much more complete and show practically all of the different bodies of soils that are of sufficient size to place on the base maps used in the field work.

During the fifteen years that elapsed between the making of the Reconnoissance Survey of the San Diego Region and the recently completed detailed surveys, much progress has been made in soil science and in the recognition and interpretation of soil characteristics in the field and laboratory. By reason of recent progress in the basic sciences, particularly chemistry and physics, there are now available means of measuring soil differences that formerly could only be approximated. This has made possible a better understanding of soil morphology[5] and a material advance in soil classification. During the field work the soils were studied in place, in their natural condition, and the details of the soil profile and their several horizons carefully noted (fig. 4). After these extensive studies in the field, areas representative of selected soil types were located, samples were taken from each horizon of the profile and subjected to physical and chemical study in the laboratories to supplement the data gathered in the field.

As a result of these studies the new surveys are not only more detailed in the mapping but also are much more complete and definite in the soil descriptions. New series of soils not recognized in the broader classification of the Reconnoissance Survey have been discovered, studied, described, and named; better correlation between the soils of these areas and other parts of the state has caused many changes in series names (table 1) and old series have been more specifically defined. This paper sets forth the salient relationships and differences of the soils of San Diego County and the changes that have been made from the classification in the Reconnoissance Survey. No attempt is made to give full details of individual soil descriptions; these will appear in the surveys of the Oceanside, Capistrano, and El Cajon areas.

An evaluation or comparative rating of the soils in the three detailed surveys is included in this paper. This is a rating on a percentage basis of all the soil types, soil phases, and miscellaneous materials as mapped in the surveys. Using this rating, or index, the soils are divided into six grades and their distribution shown on maps of the three areas.

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[5] This and other technical terms are defined in the "Glossary of Soil Terms," page 38.

PHYSIOGRAPHY AND TOPOGRAPHY

The portion of San Diego County covered by these surveys consists of two broad physiographic divisions: a coastal plain from 1 to 18 miles in width composed of flat-topped marine terraces, in places badly cut by erosion; and a mountainous highland district of crystalline rocks that

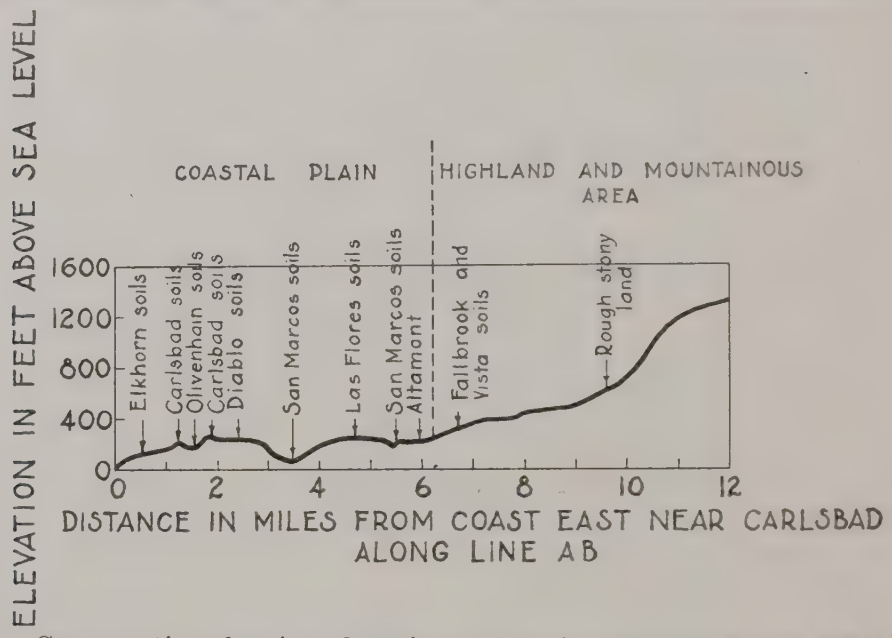


Fig. 2—Cross section showing elevation and major soils along line *AB* (fig. 1) through Carlsbad. Major physiographic divisions also shown.

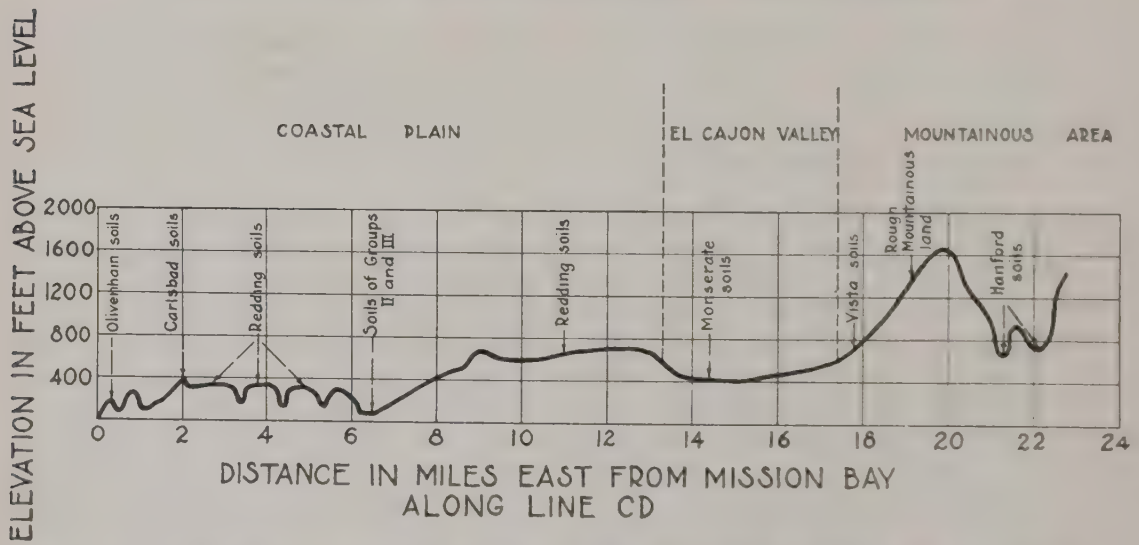


Fig. 3—Cross section showing elevation and major soils along line *CD* (fig. 1) through Mission Bay and El Cajon Valley.

covers all the remainder or the eastern portion of the area (figs. 2 and 3). The boundary between the coastal plain and the highland district coincides with that between soil groups IV and I as shown on the sketch map (fig. 1). The coastal plain is dissected by stream channels, many of them heading in the eastern portion and draining the mountainous area.

The Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, and Tia Juana rivers all have fairly large drainage areas and also have accumulated the extensive alluvial deposits along their lower courses which form the recent soils of group II.

A number of box-like valleys occur at or near the break between the coastal plain and the mountains. These are filled with alluvial deposits of different ages that give rise to maturely weathered, moderately weathered, and unweathered soils of groups IV, III, and II. The Escondido, Poway, and El Cajon valleys are the largest and most typical of these filled valleys.

Geologically, the coastal plain is made up of tertiary deposits of clay beds, shales, sandstones, conglomerates, limestones, and other slightly to moderately consolidated material; while the mountainous district is of igneous rock material mainly granitic in character (fig. 6). Sandy beach deposits occupy some of the terraces immediately bordering the coast.

The coastal plain rises from sea level to an elevation of 200 to 600 feet. The maximum elevation of the upland region exclusive of a few high peaks is about 2,700 feet above sea level in the vicinity of Alpine.

SOILS: GROUPING AND DESCRIPTIONS

Climatic factors such as precipitation, temperature, humidity, etc., have a marked effect on the soils of any region. The western part of San Diego County receives from 8 to 20 inches of rain, most of which falls during the winter months. The lowest amount is received along the coast and increases eastward. Winters are warm with little frost on the coastal plain, while the summer heat is considerably tempered by cool breezes from the ocean and occcasional high fogs which intercept the sun's energy and reduce the heat and evaporation. Under these conditions vegetation grows freely during winter when the soils are covered with grass and herbage, but by midsummer these have dried up and the soil is dry and often bare. Under these climatic influences the rainfall does not penetrate deeply into the soil, most of it being used by the growing vegetation during the rainy season. The soils usually are leached only through the surface horizons, are low in organic matter, and prevailingly grayish brown, although there is a rather wide range in color.

Differences in parent material, degree of weathering, method of formation, and lime content have all contributed their share to the diversity of soils encountered. The soils of the highland area generally occur on rolling to mountainous topography where the composition of the parent material has considerable influence on the character of the resulting soils. These soils usually exhibit a youthful or only slightly weathered

profile. Coarse crystalline rocks such as granite give sandy loam soil, while the denser rocks produce finer-textured heavier soils. Bedrock is usually encountered at a shallow depth under such conditions.

The soils of the stream valleys consist of outwash from the upland region; they exhibit young or immature profiles and have a wide range in color and in lime and alkali content.

The coastal plain soils have light to medium-textured surface horizons and heavy clay subsoils. Of these the Olivenhain, Tierra, and Las Flores series have a typical solonetz subsoil (horizon B), with the columnar structure and alkaline reaction in this horizon, while the Redding series have heavy-textured subsoils of distinctly acid reaction without the solonetz structure.

In any system of soil classification a broader or more comprehensive idea can be had of the soils of a district if they can be grouped together on the basis of common characteristics, especially when these are correlated with common agricultural values. In the San Diego Reconnoissance Survey the soils are placed in three broad groups defined as (1) residual soils derived through the disintegration or weathering in place of consolidated rocks, (2) soils derived through the weathering and modification of old unconsolidated waterlaid deposits, and (3) recent alluvial soils.[6] In the detailed surveys of the Capistrano, Oceanside, and El Cajon areas, this scheme has been further elaborated to include four main groups of soils, namely: group I, primary or residual soils derived through the weathering in place of consolidated rocks with the development of soils having young or immature profiles and which usually have the bedrock or parent material occurring less than 6 feet from the surface; group II, unweathered secondary soils from alluvial material occurring in river valleys and on alluvial fans, without definite horizon development and more than 6 feet in depth; group III, slightly to moderately weathered secondary soils from alluvial or coastal plain materials having permeable subsoils and substratum to depths of 6 or more feet; group IV, weathered secondary soils from old alluvial or coastal plain materials having dense or relatively impermeable heavy clay subsoils or hardpan horizons formed as the natural result of soil weathering processes.

The four groups of soils listed below are separated on the basis of maturity of profile and mode of formation. The soil series in each of these groups have been further subdivided into subgroups on the basis of reaction of the soil mass (table 1). In this table soil series are shown

[6] Holmes, L. C., and R. L. Pendleton. Reconnoissance soil survey of the San Diego Region. Field Operations of the Bureau of Soils, 1915. 77 p.

in subgroups having common reaction characteristics and surface soil colors, as well as profiles of comparable age and a common mode of formation. It will be noted that soil series in a subgroup have similar agricultural values.

GROUP I, PRIMARY SOILS

Group I consists of primary soils with youthful to immature profiles, formed in place by the weathering of parent bedrock or substratum. They occur on rolling to mountainous topography east of the coastal plain.

Subgroup a, Noncalcareous Soils and Subsoils.—

Fallbrook series
Vista series
Konokti series
Escondido series
Las Posas series
Carlsbad series
Ysidora series

TABLE 1

CLASSIFICATION OF SOILS OF WESTERN SAN DIEGO COUNTY AND SOUTHERN ORANGE COUNTY

Subgroup (reaction of soil profile)	Composition of parent material	Color of surface soil	Series	Type	Series names as shown in reconnoissance of 1915
			As shown in detailed surveys		
GROUP I, PRIMARY SOILS					
a Noncalcareous soils and subsoils	granitic	light brownish red or reddish brown	Fallbrook	sandy loam fine sandy loam fine sandy loam, stony phase	Sierra
	granitic	brown or grayish brown	Vista	sandy loam sandy loam, stony phase	Holland
	mixed, schists	yellowish brown	Escondido	very fine sandy loam very fine sandy loam, stony phase stony very fine sandy loam	Sierra
	mixed basic igneous	brown	Konokti	stony loam gravelly loam	Olympic
	mixed basic igneous	brownish red	Las Posas	fine sandy loam stony fine sandy loam	Aiken
	mixed sedimentary	brown	Ysidora	gravelly sandy loam gravelly sandy loam, dark-colored phase	Olympic
	sandstone	brown	Carlsbad	loamy fine sand loamy fine sand, gravelly phase	San Joaquin

TABLE 1—(*Continued*)

Subgroup (reaction of soil profile)	Composition of parent material	Color of surface soil	Series (As shown in detailed surveys)	Type (As shown in detailed surveys)	Series names as shown in reconnoissance of 1915
GROUP I, PRIMARY SOILS (*Continued*)					
b Non-calcareous surface, calcareous subsoil and bedrock	calcareous-sedimentary	light brown	Altamont	fine sandy loam clay loam clay loam, gravelly phase clay	
	calcareous-sedimentary	dark gray	Diablo	clay adobe clay adobe, steep phase clay adobe, brown phase	Diablo or Montezuma
c Calcareous soils and subsoils	calcareous-sedimentary	brown	Ayar	clay loam clay	
	calcareous-sedimentary	dark brownish gray	Linne	loam sandy clay loam clay stony clay	
GROUP II, UNWEATHERED SECONDARY SOILS					
a Non-calcareous soils and subsoils	granitic	light brown	Hanford	sandy loam sandy loam, gravelly phase fine sandy loam	Hanford
	granitic	light gray or light brownish gray	Tujunga	fine sand	Tujunga
	mixed sedimentary	light brownish gray	Laguna	loamy sand loamy fine sand sandy loam	Yolo
b Calcareous soils and subsoils	granitic	light gray	Cajon	sand fine sand fine sandy loam	Hanford
	granitic	dark brownish gray	Foster	fine sandy loam very fine sandy loam very fine sandy loam, gray phase	Foster
	mixed calcareous sedimentary	dark gray	Agueda	clay loam	Dublin
	mixed	dull brownish gray	Alviso	loam very fine sandy loam	Tidal Marsh

TABLE 1—(*Continued*)

Subgroup (reaction of soil profile)	Composition of parent material	Color of surface soil	Series	Type	Series names as shown in reconnoissance of 1915
			As shown in detailed surveys		
GROUP III, SLIGHTLY TO MODERATELY WEATHERED SECONDARY SOILS					
a Non-calcareous profile, slightly to moderately acid surface soils	sandy coastal plain	brown	Marina	loamy sand loamy fine sand	Kimball
	sandy coastal plain	brown	Elkhorn	loamy sand	Kimball
b Non-calcareous soils and subsoils	granitic	brown	Greenfield	sandy loam sandy loam, calcareous subsoil phase	Ramona or Hanford
	granitic	brown	Ramona	sandy loam sandy loam, stony phase	Ramona
	mixed	brown	Hames	sandy loam sandy loam, friable subsoil phase	Kimball
	largely sedimentary	dull brownish gray	Botella	loamy sand fine sandy loam sandy clay loam sandy clay loam, brown phase	Dublin
c Non-calcareous surface soils, calcareous subsoils	granitic	dark brownish gray	San Marcos	fine sandy loam loamy fine sand	Foster
	largely sedimentary	light brown	Sorrento	clay loam	Yolo
	largely basic igneous	dark brown	Farwell	gravelly sandy loam	Yolo
	calcareous sedimentary	dull gray	Commatti	sandy loam	Yolo or Dublin
	mixed	dull brownish gray	Salinas	sandy loam fine sandy loam fine sandy loam light-colored phase loam clay loam	Yolo
	mixed	dark gray	Clear Lake	loam sandy clay loam	Dublin

TABLE 1—(*Concluded*)

Subgroup (reaction of soil profile)	Composition of parent material	Color of surface soil	Series	Type	Series names as shown in reconnoissance of 1915
			As shown in detailed surveys		
GROUP IV, SEMIMATURELY OR MATURELY WEATHERED SOILS					
a Acid soils and subsoils—with hardpans	mixed	reddish brown	Redding	gravelly sandy loam stony sandy loam sandy loam	Redding or rough broken land
b Non-calcareous soils and subsoils resting on a consolidated substratum	mixed marine terrace	light brown	Olivenhain	loamy fine sand gravelly sandy loam	Las Flores
	mixed marine terrace	light gray	Las Flores	fine sandy loam fine sandy loam, friable subsoil phase	Las Flores and Kimball undifferentiated
	mixed marine terrace	dull brownish gray	Tierra	sandy loam loam	
c Non-calcareous surface soils, calcareous subsoils	granitic	light reddish brown	Merriam	sandy loam fine sandy loam fine sandy loam, clay phase	Placentia
	mixed	reddish brown	Aliso	sandy loam fine sandy loam fine sandy loam, heavy phase	Kimball
	mixed	light brownish gray or light grayish brown	Huerhuero	fine sandy loam	Las Flores and Kimball, undifferentiated
	mixed	light gray	Stockpen	fine sandy loam fine sandy loam, heavy-textured phase	Las Flores
	mainly sedimentary	dark gray	Montezuma	clay adobe	Montezuma
d Non-calcareous surface soils, calcareous subsoils, hardpan-like substratum	mixed	brown	Monserate	sandy loam	Placentia

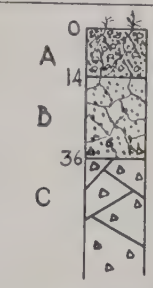
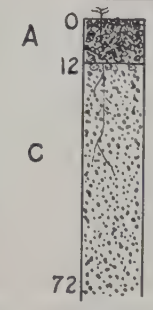
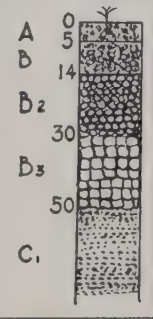
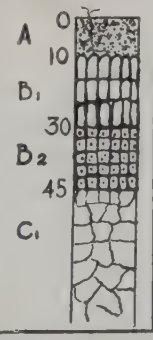
Soil Type	Profile	Color	Texture	Structure	Consistence and Density
Vista sandy loam Group Ia		light grayish brown	sandy loam	granular	friable
		brown	gritty loam	medium cloddy	moderately compact
		granitic bedrock			
Hanford sandy loam Group IIa		light brown	sandy loam	granular	friable
		light brown	variable - textured	structureless	friable
Ramona sandy loam Group IIIb		brown	sandy loam	granular	friable
		rich brown	sandy loam	medium granular	slightly compact
		reddish brown	loam	nut structure	moderately compact
		dull reddish brown	sandy clay loam	cubical	fairly compact dense, hard
		brown	loam	amorphous	slightly compact
Merriam sandy loam Group IVc		brown	sandy loam	granular	friable
		dull brownish red	clay	columnar (solonetz)	very compact dense and hard
		brown	clay or clay loam	cubical	compact and hard
		light brown	varible - textured	cloddy	fairly compact and hard

Fig. 4.—Soil profiles shown diagrammatically with one soil from each major group. All four soils are derived from acid igneous (granitic) material.

Soils in this subgroup have surface soils of brown or reddish-brown color with brown, reddish-brown, red, or yellowish subsoils. Bedrock usually occurs at a depth of from 1 to 4 feet from the surface. Stones are often present in shallow areas or on steep slopes. A moderate degree of leaching and of downward migration of clay is indicated by a small but definite accumulation of colloidal clay in the subsoils. The moisture-holding capacity of the surface soils is low to medium, and the subsoils slightly higher. Both surface soils and subsoils give reactions of pH 6.6 to 7.2. In other parts of the state where the rainfall is much heavier (30

to 60 inches) soils from the same kind of parent material are distinctly acid in reaction (pH 5.7 to 6.3).

The Fallbrook and Vista series of soils are formed by the weathering in place of granitic rocks. The Fallbrook is light red to reddish brown with a redder, denser, and heavier-textured subsoil, while the Vista is brown or light brown throughout the profile (fig. 4) with less evidence of clay accumulation in the subsoil. In the Reconnoissance Survey they were included with the Sierra and Holland series, respectively, which they resemble in many respects, differing particularly by being more basic in reaction. The Sierra and Holland soils are formed where the rainfall is much heavier and the effects of leaching much more evident, while the Fallbrook and Vista are their equivalents formed under more arid conditions. The Fallbrook and Vista soils are all of light (sandy) texture. Coarse sandy loam, stony sandy loam, and fine sandy loam types occupy a large acreage over the highland (fig. 5) area, interspersed with rough mountainous and rough stony land (fig. 6), and, where sufficient water is available for irrigation purposes and where the topography is favorable, are considered desirable for a wide range of crops.

The Escondido soils are yellowish brown to reddish brown with very friable subsoils resting directly on the disintegrating schistose parent bedrock. They were included with the Sierra soils in the Reconnoissance Survey, from which they differ in profile characteristics and in origin. The soils are of very fine sandy loam or silt loam texture and are of good agricultural value where the stone content is not too high and the soils of good depth over the bedrock.

The Konokti and Las Posas series are derived from basic igneous rocks (diorites, diabases, etc.) and occur along the boundary between the coastal plain and the upland regions. In the Reconnoissance Survey the brown-colored Konokti was included with the Olympic and the brownish-red Las Posas with the Aiken series. They resemble the Olympic and Aiken series but, since they were formed under more arid conditions, are more basic in reaction. Limiting factors for agricultural use are the steepness of slopes, stone content, and relatively shallow depth in certain areas.

The Carlsbad series in the Reconnoissance Survey was included in the San Joaquin series, but the more detailed studies showed that instead of being a hardpan, the red sandstone-like material beneath the soils is a substratum of parent material from which they are being weathered (fig. 7). They occupy elevated ridges paralleling the coast. The soils are brown, sandy, and contain large quantities of small rounded concretions

("iron pellets"). Subsoils are similar to the surface soils, without any clay accumulation, and rest on the standstone-like substratum at depths of 2 to 5 feet. The organic content and general fertility of the Carlsbad



Fig. 5.—Area of Vista and Fallbrook soils, east of El Cajon. Note rough stony areas in distance and rock outcrops in foreground.



Fig. 6.—Rough mountainous area east of coastal plain shown as *R* on the sketch map (fig. 1). Note small area of tillable land.

series of soils is low, but good results are being secured with bulbs, truck crops, etc., where the soil is heavily fertilized, since the sandy texture makes it easy to handle.

The Ysidora soils are brown and rest on a grayish-brown hardpan-like parent material at depths of 1 to 3 feet. Subsoils are variable, consisting of brown, fairly compact material that may range in texture from a

sandy loam to a clay. The series occurs on sloping terrace-like topography, having small mounds and depressions referred to as "hogwallows" scattered over the surface. The surface soils are of gravelly sandy loam texture. Soils of this series are of low agricultural value on account of their variable depths and uneven surface. The Ysidora was included with the Olympic series in the Reconnoissance Survey.



Fig. 7.—Profile of Carlsbad loamy fine sand, east of Oceanside, included in group I. Note the hardpan-like substratum.

Subgroup b, Noncalcareous Surface Soils, Calcareous Subsoils, and Calcareous Parent Materials.—

Altamont series
Diablo series

The Altamont and Diablo series are derived from calcareous sedimentary rocks and occur on the coastal plain. The Altamont soils are light brown or brown, while the Diablo is dark gray. Subsoils are of somewhat grayer color in each case, are calcareous, and have a somewhat greater amount of colloidal clay than the surface soils. Highly calcareous bedrock from which the soils are derived occurs at depths of 2 to 4 feet. Both soils normally occur on a gently sloping surface, but occasionally on fairly steep slopes. The Diablo soils are shown on the Reconnoissance map, but the Altamont soils were included with the Diablo series, being described as soils of a browner color than typical Diablo.

The Altamont series has fine sandy loam, clay loam, and clay types, while the Diablo series has clay adobe types. The clay loam types are shallower and more subject to erosion than the clay types. The heavier types are fertile but more difficult to till owing to their stickiness when wet and hardness on drying.

Subgroup c, Calcareous Soils and Subsoils.—

Ayar series
Linne series

The Ayar series has brown soils and subsoils, while the Linne series has dark gray or dark brownish-gray soils and subsoils. The lime content is high in both the surface soils and subsoils, and the latter usually contain pieces of marly bedrock from which the soils have been derived. The upper part of the parent bedrock, which is usually found at depths less than 3 feet, is soft. The extremely granular structure of the soils and subsoils seems to mask the heavy texture and causes them to appear lighter than a clay or clay loam, which a mechanical analysis proves them to be. Both soil series occur on the higher coastal plain region on a flat to gently sloping surface. The soils have a high moisture-holding capacity, are sticky when wet, but are friable at the ordinary field moisture content, due to the flocculating effect of the lime present in the soil mass. Good yields of grain, grain hay, and beans are secured when sufficient rain falls.

In the Reconnoissance Survey the Linne was included in the Montezuma series, with the Ayar described as a browner inclusion. They do not properly belong with the Montezuma, which is derived from different parent material and has noncalcareous surface soils as well as other differences in profile characteristics.

GROUP II, UNWEATHERED SECONDARY SOILS

Group II consists of unweathered secondary soils formed by deposits of recent alluvial material, occurring in river valleys and on alluvial fans or alluvial slopes.

Subgroup a, Noncalcareous Soils and Subsoils.—

Hanford series
Tujunga series
Laguna series

Soils of the Hanford and Tujunga series are derived from granites, while the Laguna is derived from coastal-plain material of sedimentary origin. All occupy recent alluvial fans and flood plains and have deep, sandy, permeable soils and subsoils. They have been deposited under conditions of good drainage and have no accumulation of alkali or lime.

The Hanford soils are of a light brown or brown color in surface soil and subsoil. The surface soils are generally sandy loams and the subsoils often stratified with alternating layers of sandy loams and sands. The soil material is all highly micaceous, of medium to low moisture-holding capacity and of fair to good organic content. They are of a high productive capacity and suited to a wide range of crops.

The Tujunga soils are of light gray or light brownish-gray color and of coarse texture, the fine sand type predominating. They usually border present stream channels, being of very recent deposition. The soils are raw, often excessively permeable, of low moisture-holding capacity and of low organic content, all of which renders them of somewhat less productive value than the Hanford.

The Laguna soils are light brownish gray in color generally of loamy sand or sandy loam texture. They are generally of somewhat lower productive capacity than the Hanford series because the soil material had its origin in the poorer, sandy coastal plain material of leached character.

Hanford and Tujunga soils were so mapped in the Reconnoissance Survey. Owing to their small extent the Laguna soils were included with the Yolo series, from which they differ in being of lighter color and of poorer quality.

Subgroup b, Calcareous Soils and Subsoils.—

Foster series
Cajon series
Agueda series
Alviso series

Soils of the Foster and Cajon series are derived from granitic outwash material under conditions of restricted drainage with an accumulation of lime from calcareous waters. They are often saline in the lower-lying areas.

Foster soils are of dark brownish-gray color, while the Cajon series are light gray. Cajon soils usually border stream channels, are of light sandy texture, low moisture-holding capacity and subject to overflow. These factors limit their agricultural use. The Foster soils are of medium texture, have a moderate organic content, hold considerable moisture, and are utilized for alfalfa, field, and truck crops. In general they are not adapted to fruit culture because of the drainage and alkali problem. The Cajon series was included with the Hanford in the Reconnoissance Survey.

The Agueda soils occur on outwash from the dark-colored calcareous soils of the Linne series. Both surface and subsoils are of dark brownish-

gray or dull-gray color, of loam, clay loam, or clay texture, granular structure, and high moisture-holding capacity. This soil is well drained, contains no alkali, and is adapted to field crops. It is extensively used for beans. The Agueda was mapped as the Dublin in the Reconnoissance Survey. It differs from the Dublin in lime content, as well as in other features, such as origin.

Alviso soils occupy low tidal marsh land that has been derived from mixed rock material. They are of dull brownish-gray color and are rather variable in texture and to a large extent have been reworked by the action of the tides as the water moves in and out of the lagoons. They are poorly drained and highly saline, and therefore of little value at the present time. Ultimately certain areas may be reclaimed by building levees and then leaching with fresh water. The Alviso series was included with Tidal Marsh in the Reconnoissance Survey.

GROUP III, SLIGHTLY TO MODERATELY WEATHERED SECONDARY SOILS

Group III consists of slightly to moderately weathered secondary soils from alluvial or coastal plain materials, with subsoils slightly or moderately denser and heavier in texture than surface soils.

Subgroup a, Noncalcareous Profile; Leached Marine-Terrace Soils.—

Marina series
Elkhorn series

The Marina and Elkhorn series are the result of weathering of sandy coastal-plain deposits immediately joining the shore line. Both have sandy surface soils of light brown, medium brown, or light grayish-brown color. When moist the soils appear to be of a reddish-brown color. The surface soils are low in humus, somewhat leached, and slightly to moderately acid in reaction. Subsoils are of about the same texture as the surface, of yellowish-brown color, but more dense. Subsoils of the Elkhorn series are more compacted than those of the Marina series and represent an older, more maturely weathered development. Elkhorn subsoils when dry appear semicemented and are somewhat difficult to penetrate with a pick or shovel.

These soils are being utilized for avocados, bulbs, flowers, and winter vegetables. Because of their nearness to the ocean, climatic conditions seem ideal. The surface soils are friable and easy to till, but lacking somewhat in humus and general fertility. Barnyard manures, bean straw, and commercial fertilizers are extensively used in supplying this need. The Marina and Elkhorn soils were included with the Kimball

series in the Reconnoissance Survey, but the detailed studies brought out many differences in profile characteristics. These two series have recently been mapped in Monterey County.

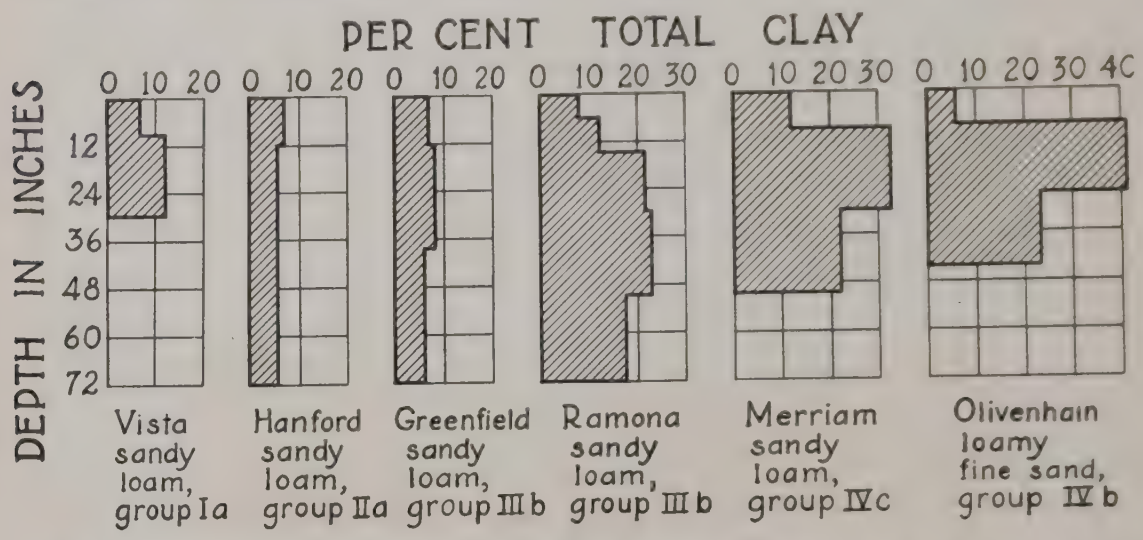


Fig. 8.—Total clay content of selected soils in each group by horizons. Note that the clay content in the subsoil of the Ramona sandy loam is considerably greater than that in the same horizon of the Greenfield or Hanford sandy loams.

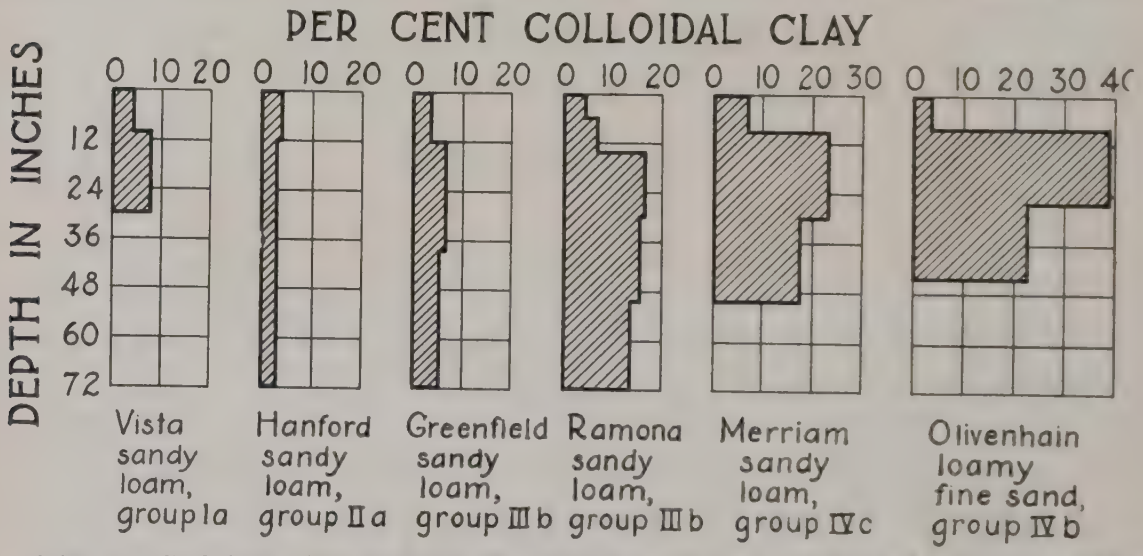


Fig. 9.—Colloidal clay content of selected soils in each group by horizons (the same soils are in fig. 8). The colloidal clay content in the subsoils increases with the maturity of the soils. The moderately weathered Ramona sandy loam has a much greater content of colloidal clay than the unweathered Hanford sandy loam.

Subgroup b, Noncalcareous Soils and Subsoils.—

Greenfield series
Ramona series
Hames series
Botella series

Soils of the Greenfield and Ramona series are derived from granitic parent material and represent two stages of soil weathering beyond the immature Hanford series. Both soils are brown in color and highly mica-

ceous. Greenfield soils have a slight accumulation of colloidal clay and a moderate degree of compaction in the subsoils, while the Ramona soils have the greater accumulation of colloidal clay and the denser and more compact subsoil characteristic of an older soil (figs. 8 and 9). Considerable colloidal glazing in cracks and on the faces of lumps and clods is in evidence in the Ramona subsoils, but is absent from the Greenfield.



Fig. 10.—Recent alluvial soils of group II in foreground, Ramona soils of group III on the terrace, and primary soils of group I on the hills. Note the erosion on the terrace.

The colloidal clay content in the B horizon of the Greenfield is usually about 7 per cent, while the same horizon of the Ramona has from 12 to 16 per cent of colloidal clay. Surface soils are predominantly of sandy loam texture. The Ramona soils occur on terraces or elevated benches (fig. 10), while the Greenfield lie on alluvial fans or lower alluvial terraces. The soils are well drained, readily penetrated by water or plant roots, and are considered desirable for a wide range of crops. Both are valuable citrus soils of southern California. The Greenfield series was included with the Ramona or Hanford soils on the Reconnoissance map.

The Hames soils are of brown or light brown color and similar in age and general profile development to the Ramona series, but are derived from material of mixed geological origin and lack the micaceous particles and quartz grains found so abundantly in the Ramona profile.

The surface texture is a sandy loam. Agriculturally, it has about the same value as the Ramona and Greenfield soils. It was included with the soils mapped as the Kimball series in the Reconnoissance Survey, but was established as a distinct series in the more recent surveys.

Botella soils are derived largely from coastal plain sedimentary material of nonmicaceous character and are of dull grayish-brown or dull brownish-gray color. The profile shows a slight accumulation of colloidal clay in the subsoil along with a moderate degree of compaction. The C horizon is made up of variable-textured, friable alluvial soil material extending to more than 6 feet in depth. Normally these soils occur on well-drained alluvial slopes or low terraces, although in a few places slightly mottled subsoils are an evidence of local poor-drainage conditions. The soils are well supplied with organic matter, contain no alkali, and are considered very desirable for general field and truck crops. Three types are mapped in the detailed surveys, Botella loamy sand, Botella fine sandy loam, and Botella sandy clay loam. The first two sandier types are easier to till than is the sandy clay loam, which has a higher colloidal clay content, rendering the soil sticky and plastic when wet. The Botella soils were included with the Dublin in the earlier Reconnoissance Survey. They differ from the Dublin in being of lighter color, having denser and more colloidal subsoils, and in other profile characteristics.

Subgroup c, Noncalcareous Surface Soils and Calcareous Subsoils.—

San Marcos series
Salinas series
Sorrento series
Farwell series
Commatti series
Clear Lake series

Soils of the San Marcos series are derived from granitic or micaceous rocks and are of dark brownish-gray color. Subsoils are of the same color or slightly darker, mottled, highly calcareous, and only slightly heavier in texture and slightly more compact than the surface. San Marcos soils are subject to overflow and to poor drainage conditions during the winter and spring months. Alkali is present over a large portion of these soils, which along with poor drainage limits agricultural development. Loamy fine sand and fine sandy loam types have been mapped in the recent detailed surveys. This series was included with the Foster in the Reconnoissance Survey but in the recent surveys has been differentiated on the basis of the noncalcareous surface.

The Salinas series has soils of dull brownish-gray or dark grayish-brown color with a slightly weathered profile, and moderately calcareous subsoils. These soils have their origin in a variety of rocks. Types of sandy loam, fine sandy loam, loam, and sandy clay loam texture have been mapped in the surveys. All are considered of high value for truck and field crops because they are fertile and easy to till and irrigate. They have good drainage and do not contain alkali. Frost conditions limit certain crops in some of the narrow valleys where the soils are located. Soils of this series were mapped in recent surveys in Monterey and San Luis Obispo counties. In the Reconnoissance Survey they were included with the soils mapped as Yolo.

The Sorrento soils are similar in profile to those of the Salinas series, differing in being of light brown or brown color and derived from alluvial material mainly of sedimentary rock origin. Subsoils are light brown, slightly compact, with a slight clay accumulation, and slightly calcareous. The series is developed on smooth valley floors and slopes on which drainage is good. The soils are of good moisture-holding capacity and fertility and with irrigation and favorable temperature are adapted to a wide range of crops. In the Reconnoissance Survey they were mapped as the Yolo, but are now recognized as a new series similar to the Yolo series but developed under lower rainfall and having a slightly weathered profile with a slight accumulation of lime. Only one type, the Sorrento clay loam, has been mapped in the detailed areas.

The structural development, compaction, and lime content in the subsoils of the Farwell series are about the same as in the Sorrento and Salinas, but the soils differ in being of dark brown color and in being derived largely from basic material. They occupy alluvial fans and terraces along the coast between the mouth of Horno Canyon and Laguna Beach, where there is considerable outwash from schistose material. The gravelly sandy loam type has been mapped. The soil has about the same value and is used for the same crops as the Sorrento and Salinas series. As with the others, the series was included with the Yolo of the Reconnoissance Survey.

The Commatti series is characterized by dull gray to brownish-gray surface soils and slightly compact and heavier-textured calcareous subsoils of about the same color. The soils are derived mainly from calcareous sedimentary rocks and occupy alluvial fans and low terraces of similar position to the other soil series of this subgroup, although of somewhat greater age as evidenced by the heavier-texture subsoil. Surface soils are of sandy loam texture, friable, easy to till, and of a good moisture-holding capacity, although they are low in organic matter.

Where climatic conditions are favorable, these soils are adapted to a wide range of crops. They were included with both the Yolo and Dublin series in the Reconnoissance Survey.

The Clear Lake soils are of mixed origin and have a dark gray or black surface soil, an upper subsoil of about the same color, but of slightly heavier texture, moderately compact and with some lime accumulation, and a lower subsoil of light brownish-gray or dull brownish-gray, slightly mottled, calcareous clay loam. Surface soils are of loam or sandy clay loam texture. They occupy flat benches or stream bottoms and have poor subdrainage, which makes them not so well adapted to development as the other soils of the subgroup. Surface soils are well supplied with organic matter and are absorptive and retentive of moisture. The Clear Lake series was included with Dublin in the Reconnoissance Survey, but is now separated, mainly because of the lime content in the subsoils.



Fig. 11.—Redding gravelly sandy loam (group IV), east of Del Mar, showing gravelly and cobbly substratum, shallow depth of soil, and low brush cover.

GROUP IV, WEATHERED SECONDARY SOILS

Group IV consists of weathered secondary soils from old alluvial or coastal plain materials with heavy clay subsoils. These soils usually occur on terraces of the coastal plain.

Subgroup a, Acid Soils and Acid Subsoils, Thoroughly Leached.—

Redding series

The Redding soils are characterized by a light reddish-brown surface layer of gravelly sandy loam, sandy loam, or stony sandy loam texture 5 to 10 inches thick and a subsoil layer of deep red, compact clay 10 to 20 inches in thickness that rests on a thick cobbly cemented hardpan-like substratum. Often a true hardpan of red silica and iron-cemented mate-



Fig. 12.—Profile of Olivenhain loamy fine sand, group IV. Note the columnar (solonetz) B horizon and the consolidated C horizon consisting of marine sediments.

rial with many imbedded rounded stones 1 to 4 inches in diameter rests directly on top of the thick substratum. Often a layer of highly colloidal, drab-colored clay overlies the hardpan (fig. 11). All horizons are distinctly acid (pH 4.4 to 6.0). This represents one of the most acid soils of the state. Redding soils occur on high flat-topped mesas and are derived from material of mixed origin that has been maturely weathered. The shallow depth and the high content of gravel and stone limit the use of these soils. The stony sandy loam type includes steep, eroded areas in the Poway Hills and has a high content of stone. These steeper areas were included with rough broken land in the Reconnoissance Survey. Redding types are of very low value.

Subgroup b, Noncalcareous Soils and Subsoils Resting on a Partially Consolidated Substratum (Solonetz-like Soils).—

Olivenhain series
Las Flores series
Tierra series

These coastal plain soils are developed on old marine-terrace deposits and have surface soils that are friable, permeable, and of loamy fine sand, fine sandy loam, sandy loam, or loam texture. The surface soil at a depth of 6 to 10 inches rests abruptly on an extremely waxy tenacious clay or sandy clay layer that has a definite columnar or solonetz-like structure on drying (fig. 12). This is slowly permeable to water and difficult of penetration by roots. When moist, it is extremely sticky and when dry very hard. From 85 to 95 per cent of the clay content of the solonetz horizon is colloidal (fig. 13). The clay layer rests directly on the moderately consolidated sandstone-like marine substratum at a depth of 12 to 36 inches from the surface. Surface soils are slightly acid (pH 6.0 to 6.6), while the clay layer is decidedly basic (pH 7.1 to 8.5). The parent material contains a moderate amount of sodium chloride and other soluble salts (0.02 to 0.20 per cent). The leached surface, the heavy impervious clay layer, and the saline parent material cause these soils to be of low agricultural value. After the heavy rains during the winter of 1931–32 serious drainage problems have become evident on these soils with severe damage to permanent crops such as citrus and avocados. They are also very badly dissected by erosion in certain areas, exposing the clay subsoil or the parent material (fig. 15).

The three series may be distinguished by color. The Olivenhain has light brown surface soils and dull brown subsoils; the Las Flores has light gray surface soils and dull brown subsoils; while the Tierra has dull brownish-gray surface soils and dull brown subsoils. The parent material of the Las Flores series is of somewhat lighter color than that of the Olivenhain and Tierra. It is of a light gray sandstone-like nature (fig. 15).

On some of the steeper slopes the light gray surface of the Las Flores rests directly on the gray sandstone-like parent material without any clay horizon lying between the surface soil and the parent material.

The Olivenhain is a new soil series recognized for the first time in the Oceanside area. The Tierra was recognized as such for the first time in the Salinas area in Monterey County. Since then it has been mapped in the Paso Robles, San Luis Obispo, and Santa Ynez areas in California. These soils were all included with the Las Flores soils of the Reconnaissance Survey.

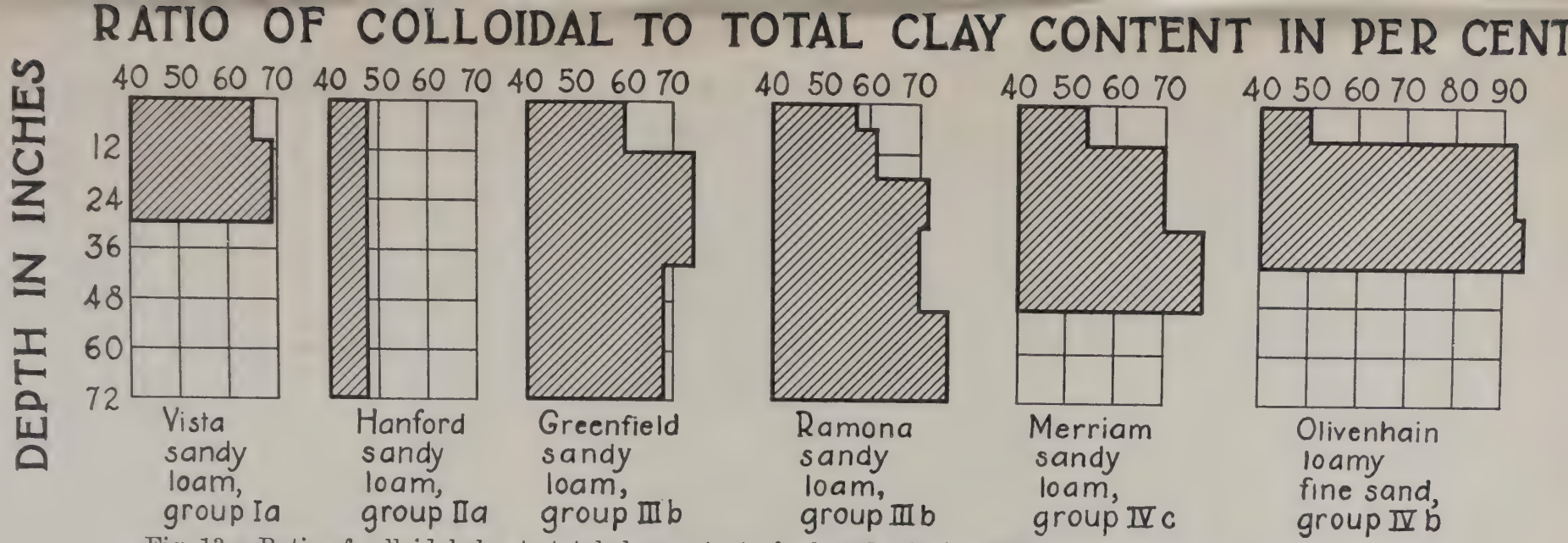


Fig. 13.—Ratio of colloidal clay to total clay content of selected soils in each group by horizons (see figs. 8 and 9).

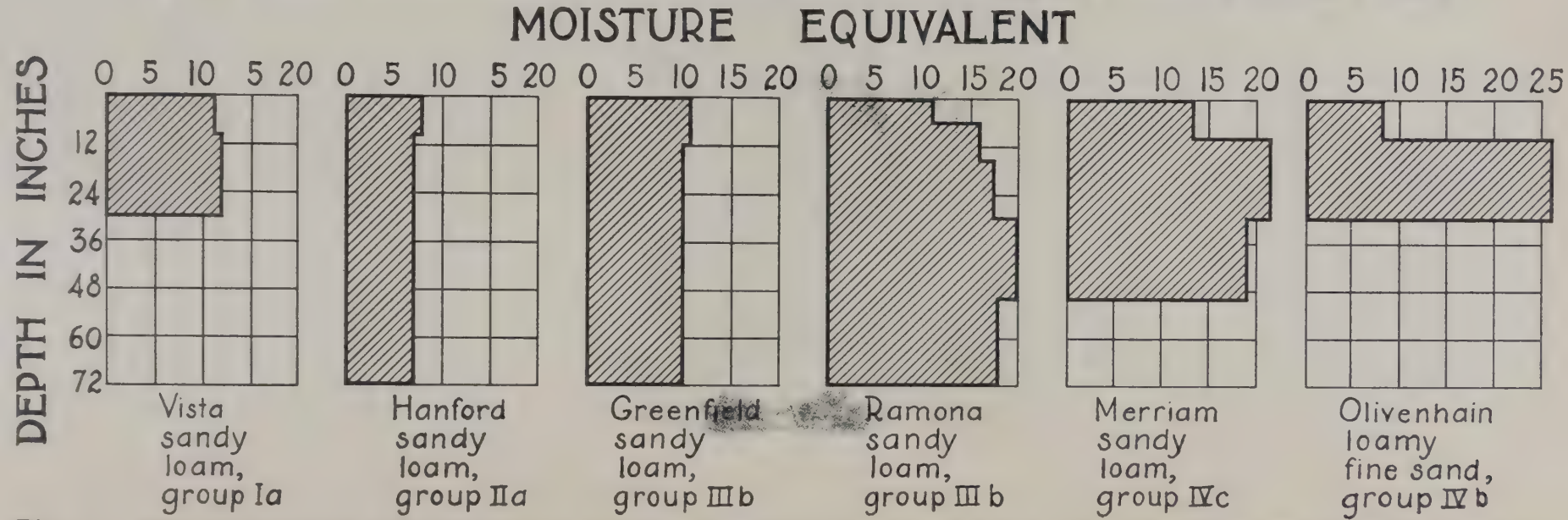


Fig. 14.—Moisture-equivalent determinations by horizons of selected soils in each group (the same soils as used in figs. 8, 9, and 13).

Subgroup c, Noncalcareous Surface Soils, Calcareous Subsoils (Solonetz Soils).—

Aliso series
Huerhuero series
Stockpen series
Merriam series
Montezuma series

The general sequence and number of the structural, consistence, textural, and reaction horizons in these soil series are similar. All occur on terrace or sloping-bench surfaces, and are fairly mature as evidenced



Fig. 15.—Erosion in Las Flores soils, group IV, 4 miles east of Oceanside. The heavy clay subsoil has a fluted appearance. These soils have infertile surface soils and very heavy intractable clay subsoils.

by the accumulation of colloidal clay in the subsoils and the nodular accumulation of lime in the lower subsoils. They differ from the Olivenhain, Las Flores, Tierra group described previously in the presence of the horizon of lime accumulation that breaks into cube-like fragments and in the less consolidated nature of the parent material. All except the heavy-textured Montezuma soils have the sharp line of demarcation between the surface soil and subsoil, with the columnar solonetz-like characteristics of this horizon.

The Aliso soils are reddish brown, the Huerhuero light brownish gray or light grayish brown, and the Stockpen light gray. These all are derived from mixed material.

Merriam soils are of light reddish-brown color and derived largely from granitic material. They are associated with the Ramona and othe

similar soils derived from granitic material and represent a fairly mature soil development of this kind of material under low rainfall.

A typical profile of a Huerhuero fine sandy loam is as follows. Aliso, Stockpen, and Merriam soils have similar characteristics (figs. 4 and 16).



Fig. 16.—Huerhuero fine sandy loam, group IV, Capistrano area. Note the sharp line of contact between surface and subsoil horizons. An accumulation of lime at a depth of about 3 feet is indicated by the arrow.

The A_1 horizon consists of 4 to 10 inches of slightly acid (pH 6.0 to 6.6) friable sandy loam or fine sandy loam; A_2 horizon of light gray laminated sandy loam 1/16 to 1/4 inch in thickness occurring as a thin coating over the clay horizon; B_1 horizon 8 to 14 inches in thickness of extremely compact columnar clay, distinctly basic in reaction (pH 7.1 to 8.5), and high in colloidal clay; B_2 horizon of compact clay loam or clay, breaking up in regular-shaped cubes with lime present as nodules and in seams and cracks; and the parent material or C horizon of a moderately compact loam or sandy loam having a pH of 7.0 to 8.0, but having practically no soluble salts present.

The detailed studies show the typical Montezuma soils to be of minor extent. Most of the soils that were mapped as Montezuma in the Reconnoissance Survey have been classified as the Diablo or Linne series on the basis of profile differences and the consolidated calcareous parent material. The Montezuma soils consist of heavy-textured (clay adobe) noncalcareous dark gray surface soils and heavy-textured lighter-colored

calcareous clay subsoils, with a lower subsoil having a cubical structu and containing nodular accumulations of lime. They are derived fro heavy-textured sediments and are underlain by a substratum of du brownish-gray, irregularly calcareous, dense but unconsolidated, claye deposits.

The soils included in this group have a somewhat higher value tha those of the preceding group (Olivenhain, Las Flores, and Tierra series since they have deeper surface soils and more permeable structure the lower subsoil, and do not have the degree of consolidation of t parent material, and the salinity so often present in the other grou The heavy relatively impervious solonetz upper subsoil horizon limi the penetration of moisture, roots, and air, making the production deep-rooted irrigated crops very difficult.

The Merriam was included with the Placentia of the Reconnoissan Survey. It is similar to the Placentia in most soil characteristics, b differs from it in having the solonetz-like B_1 horizon and accumulate lime in the B_2 horizon.

The Aliso and Huerhuero series were included with the Kimball ar Las Flores of the Reconnoissance Survey. They differ mainly in the a cumulated lime. The Aliso is a new soil series recognized for the fir time in San Diego County, while the Huerhuero was established in t Paso Robles area to include the lighter-colored more arid equivalent the Antioch series.

The Stockpen soils were included with the Las Flores of the Reco noissance Survey from which they differ mainly in their lighter col and in the presence of accumulated lime.

Subgroup d, Noncalcareous Surface Soils, Calcareous Subsoils, wi Hardpan or Hardpan-like Substratum.—

Monserate series

The Monserate series is characterized by the presence of a light brow ish-colored iron-and-silica-cemented hardpan that may be calcareous the upper portion in seams and crevices. A cubical-structured calcar ous clay layer overlies the hardpan. The A, B_1, and B_2 horizons a similar in color to those of the Aliso and Merriam series in being brow or reddish brown. The hardpan often rests on a brown, moderately co solidated substratum of similar color so that it is often difficult to dete mine the thickness of the hardpan. The hardpan or hardpan-like su stratum usually occurs at a depth of 3 to 4 feet from the surface. Mo serate soils are of mixed origin, although granitic material often sho up fairly distinctly in the profile. In the Reconnoissance Survey th were included as a hardpan variation of the Placentia.

EVALUATION OF THE SOILS

In table 2, all the soil types of the El Cajon, Oceanside, and Capistrano areas have been arranged in a comparative rating on the basis of the degree to which they present conditions considered favorable for the growth of plants. Soils presenting the most favorable general conditions



Fig. 17.—Grouping of soils of El Cajon Area, San Diego County, California, on the basis of soil index.

Grade 1—Excellent soils, index 80–100.
2—Good soils, index 60–80.
3—Fair soils, index 40–60.
4—Poor soils, index 20–40.
5—Very poor soils, index less than 20.
6—Miscellaneous nonagricultural materials, index 0–5.

are given a rating of 100 per cent, and the other soils are rated in comparison. This soil rating, or index of soil value,[7] is based on the soil factor alone and does not include the effect of local climate, availability of water for irrigation, the location, or other site factors that enter into land appraisals. In arriving at the "index" or rating on the individual

[7] Storie, R. Earl. An index for rating the agricultural value of soils. (Unpublished at the time this is written.)

TABLE 2

COMPARATIVE RATING OF THE SOILS OF THE EL CAJON, OCEANSIDE, AND CAPISTRANO AREAS IN WESTERN SAN DIEGO AND SOUTHERN ORANGE COUNTIES, ON THE BASIS OF THEIR GENERAL VALUE

Grade 1		Grade 2		Grade 3	
Excellent soils	Rating	Good soils	Rating	Fair soils	Rating
Hanford fine sandy loam	100	Botella sandy clay loam, brown phase	76	Ramona sandy loam, stony phase	58
Salinas fine sandy loam	95	Botella loamy sand	76	Marina loamy fine sand	57
Salinas fine sandy loam, light-colored phase	95	Botella loamy sand, brown phase	76	Clear Lake sandy clay loam	56
Salinas loam	95	Laguna loamy sand	76	Marina loamy sand	53
Hanford sandy loam	95	Farwell gravelly sandy loam	70	Cajon fine sand	52
Greenfield sandy loam	95	Botella sandy clay loam	69	Escondido very fine sandy loam	50
Cajon fine sandy loam	95	Clear Lake loam	66	Merriam fine sandy loam	50
Greenfield sandy loam, calcareous subsoil phase	95	Elkhorn loamy sand	62	Hanford sandy loam, gravelly phase	50
Botella fine sandy loam	95	Fallbrook fine sandy loam	60	Merriam sandy loam	48
Hames sandy loam, friable subsoil phase	95	Fallbrook sandy loam	58	Cajon sand	48
Salinas sandy loam	90	Vista sandy loam	58	Linne loam	47
Foster very fine sandy loam	90*			Fallbrook fine sandy loam, stony phase	42
Foster very fine sandy loam, gray phase	90*			Linne sandy clay loam	42
Foster fine sandy loam	90*			Las Posas fine sandy loam	42
Commatti sandy loam	90				
Ramona sandy loam	86				
Sorrento clay loam	85				
Laguna sandy loam	85				
Laguna loamy fine sand	85				
Hames sandy loam	81				
Salinas clay loam	80				
Salinas sandy clay loam	80				
Agueda clay loam	80				

* Some areas affected by alkali should be given lower value.

TABLE 2—(*Concluded*)

Grade 4		Grade 5		Grade 6	
Poor soils	Rating	Very poor soils	Rating	Miscellaneous nonagricultural materials	Rating
Huerhuero fine sandy loam	40	Carlsbad loamy fine sand, gravelly phase	20	Rough mountainous land	5
Aliso fine sandy loam	40	Ysidora gravelly sandy loam	20	Rough broken land	5
Altamont fine sandy loam	40	Ysidora gravelly sandy loam, dark phase	20	Rough stony land	2
Stockpen fine sandy loam	40	Las Flores fine sandy loam	20	Riverwash	2
Aliso sandy loam	38	Konokti stony loam	18	Tidal marsh	2
Monserate sandy loam	38	Konokti gravelly loam	18	Coastal beach and dune sand	2
San Marcos fine sandy loam	38	Altamont clay loam, gravelly phase	17		
Las Flores fine sandy loam, friable subsoil phase	35	Las Flores loamy fine sand	16		
San Marcos loamy fine sand	34	Diablo clay adobe, steep phase	15		
Ayar clay loam	34	Olivenhain gravelly sandy loam	15		
Stockpen fine sandy loam, heavy-textured phase	32	Linne stony clay	14		
Vista sandy loam, stony phase	32	Redding gravelly sandy loam	10		
Tujunga fine sand	31	Redding stony sandy loam	8		
Montezuma clay adobe	30	Las Flores loamy fine sand, eroded phase	5		
Altamont clay loam	28	Alviso loam	5		
Escondido very fine sandy loam, stony phase	28	Alviso very fine sandy loam	5		
Escondido stony very fine sandy loam	28				
Las Posas stony fine sandy loam	28				
Carlsbad loamy fine sand	27				
Merriam fine sandy loam, clay phase	25				
Altamont clay	25				
Diablo clay adobe	25				
Diablo clay adobe, brown phase	25				
Olivenhain fine sandy loam	25				
Tierra loam	25				
Tierra sandy loam	24				
Ayar clay	20				
Linne clay	20				
Olivenhain loamy fine sand	20				
Redding sandy loam	20				



Fig. 18.—Grouping of soils of Oceanside Area, San Diego County, Califor on the basis of soil index.

Grade 1—Excellent soils, index 80–100.
2—Good soils, index 60–80.
3—Fair soils, index 40–60.
4—Poor soils, index 20–40.
5—Very poor soils, index less than 20.
6—Miscellaneous nonagricultural materials, index 0–5.

soil type, inherent soil characteristics are considered, such as the depth, texture, and density of the surface soil and subsoil, reactions, alkali content, and drainage conditions. The rating covers the entire area of each soil type as occurring in these surveys, and in applying it to an indi-



Fig. 19.—Grouping of soils of Capistrano Area, San Diego and Orange counties, California, on the basis of soil index.

Grade 1—Excellent soils, index 80–100.
2—Good soils, index 60–80.
3—Fair soils, index 40–60.
4—Poor soils, index 20–40.
5—Very poor soils, index less than 20.
6—Miscellaneous nonagricultural materials, index 0–5.

vidual body of the soil on a farm, the index rating may have to be raised or lowered slightly because of local abnormal conditions.

On the basis of this rating, the soils have been placed in six grades as indicated in the table, there being a range of about 20 index points within each grade except the last. This gives a considerable range in the index rating of the soils within each grade. Figures 17, 18, and 19 show the distribution of these grades in the areas. The soils of grade 1 are scattered irregularly throughout the region in small valleys. There is a narrow belt of soils of grade 2 along the coast bordering the broad band of grades

4 and 5 soils which occupy the mesa-like areas of old marine terraces along the coastal plain. Irregular-shaped bodies of the soils of grades 2 and 3 occupy the upland area between the mesas and the mountains, interspersed with large areas of grade 6 material. The last is nonagricultural because of its stony character and mountainous topography.

SUMMARY

The Reconnoissance Soil Survey of the San Diego Region and other generalized soil surveys of southern California, the Sacramento and San Joaquin valleys, and the San Francisco Bay Region, show the soils in rather inclusive groupings. The reconnoissance surveys are now being supplanted by detailed soil surveys as rapidly as facilities permit. These detailed soil surveys are much more complete and show practically all of the different bodies of soils that are of sufficient size to place on the base maps.

During 1929 and 1930 three detailed soil surveys were made covering the western half of the area surveyed in the Reconnoissance Soil Survey of 1915. Forty different series of soils are mapped in the detailed studies, while there are eighteen soil series in the Reconnoissance Survey.

The different soils in the San Diego County areas are discussed under four main groups separated on the basis of maturity of profile and mode of formation. These have been subdivided into subgroups on the basis of reaction of the soil mass. Soil series in each subgroup have fairly similar agricultural values.

Group I: Primary soils are formed in place by the weathering of the parent bedrock or substratum on which the soils rest, and occur on the rolling to mountainous topography east of the coastal plain. The Fallbrook, Vista, Konokti, Escondido, Las Posas, Carlsbad, and Ysidora series of soils have noncalcareous profiles; the Altamont and Diablo series have noncalcareous surface soils and calcareous subsoils; and the Ayar and Linne soils have both surface soils and subsoils calcareous.

Group II: Unweathered secondary soils are formed by deposits of recent alluvial material. The Hanford, Tujunga, and Laguna series have noncalcareous soils and subsoils; the Foster, Cajon, Agueda, and Alviso series have calcareous soils and subsoils.

Group III: Slightly to moderately weathered secondary soils are derived from alluvial or coastal plain materials and have subsoils slightly or moderately denser and heavier in texture than the surface soils. The Marina and Elkhorn series have sandy leached marine-terrace soils which are the result of weathering of sandy coastal-plain deposits imme-

diately joining the shore line. The Greenfield, Ramona, Hames, and Botella series have noncalcareous soils and subsoils; while the San Marcos, Salinas, Sorrento, Farwell, Commatti, and Clear Lake series have noncalcareous surface soils and calcareous subsoils.

Group IV: These are weathered secondary soils from old alluvial or coastal plain materials. These soils usually occur on terraces and have extremely heavy clay subsoils. The Redding series has highly acid soils and subsoils. The Olivenhain, Las Flores, and Tierra series have noncalcareous surface soils and heavy clay subsoils that rest on a partially consolidated substratum at a depth of 1 to 3 feet from the surface. The Aliso, Huerhuero, Stockpen, Merriam, and Montezuma series all have a nodular accumulation of lime in the lower subsoils and a parent material of less consolidated nature than that of the Olivenhain, Las Flores, and Tierra series. The Monserate series has noncalcareous surface soils and calcareous subsoils which rest on a hardpan or hardpan-like substratum. With the exception of the Redding series all the soils in this group have solonetz characteristics.

The soils mapped in the El Cajon, Oceanside, and Capistrano detailed soil surveys have been evaluated on a comparative basis designated as the "index of soil value" and expressed as percentage. This rating is based on the soil characteristics which govern their agricultural value, such as the depth, texture, and density of the surface soil and subsoil, reactions, alkali content, and drainage conditions. On the basis of their index values the soils have been graded into 6 grades: excellent soils, good soils, fair soils, poor soils, very poor soils, and miscellaneous nonagricultural materials.

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GLOSSARY OF SOIL TERMS

*Acid soil:** a soil that is deficient in available bases, particularly calcium, and that gives an acid reaction when tested by standard methods.

Acid igneous origin: soils having their origin in material from the disintegration and decomposition of igneous and metamorphosed igneous rocks high in quartz (granites).

Accumulated lime: lime that has been developed or accumulated in a soil horizon through natural soil weathering processes.

*Alkali soil:** a soil containing any soluble salts in sufficient amount to cause injury to economic plants.

*Alkaline soil:** a soil containing an excessive amount of the alkaline (in true chemical sense) salts, usually sodium carbonate.

*Alluvial soil:** soil formed from materials transported by flowing waters and deposited as alluvial fans and flood plains.

*Amorphous structure:** a soil of fine texture having a massive or uniform arrangement of particles throughout the horizon.

Basic igneous origin: soils having their origin in material from the disintegration and decomposition of igneous and metamorphosed igneous rocks low in quartz (such as basalts).

*Calcareous soil:** a soil containing sufficient calcium carbonate to effervesce when tested with weak hydrochloric acid.

Colloidal clay: The finer or ultra-clay particles. Wherever used in this report clay particles are assumed to be less than 0.005 millimeter in effective diameter and colloidal clay less than 0.001 millimeter in effective diameter.

*Columnar structure:** a natural arrangement of the soil mass in more or less regular columns separated by vertical cleavage planes, and usually broken by horizontal cracks into sections with longer vertical than horizontal axes.

Concretions: small rounded nodules, usually made up of concentric layers, and of hard consistence, and ordinarily not larger than a pea. The most common concretions are cemented by lime or iron.

*Consistence:** soil consistence is a term expressing the degree of cohesion of the soil and the resistance opposed to forces tending to deform or rupture the aggregates. Common terms in use to express consistence are loose, friable, soft, hard, dense, compact, impervious.

Cubical structure: the natural arrangement of the soil mass into more or less regular cube-shaped blocks having the vertical and horizontal axes nearly equal.

*Granular structure:** aggregates varying in size up to 2 centimeters in diameter, of medium consistence, and more or less subangular or rounded in shape.

*Hardpan:** a horizon of accumulation that has been thoroughly cemented to an indurated rock-like layer that will not become soft when wet.

*Horizon or soil horizon:** a layer or portion of the soil profile more or less well defined, and occupying a position approximately parallel to the soil surface.

*Horizon A:** the upper horizon of the soil mass, from which material has been removed by percolating water, the surface soil. This horizon is generally sub-

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* Terms marked (*) are taken from: Shaw, C. F. A glossary of soil terms. American Soil Survey Association Bul. 9:23–58. 1928.

divided into two or more subhorizons, of which A_0 is not a part of the mineral soil, but is the accumulation of organic debris upon the soil surface. Other subhorizons are designated as A_1, A_2, etc.

*Horizon B:** the horizon of deposition to which materials have been added by percolating waters, the subsoil. This horizon may be divided into several subhorizons designated as B_1, B_2, B_3, etc.

*Horizon C:** the horizon of relatively unweathered material underlying the B horizon, the substratum. The C horizon, while often described as unweathered usually shows some modification in the upper portion and may have several subhorizons. In most cases it represents a parent material similar to that from which the soil was formed. In some cases a stratum or geological formation of material different from that of which the soil was formed may underlie the soil. With such conditions there is actually no true C horizon, the B horizons resting directly on unrelated material. In actual practice, however, this is usually called the C horizon, its character and lack of relation to the soil being brought out in the descriptions.

*Immature soil:** a soil having a profile with compact subsoil horizons with distinct clay accumulations; moderately weathered immature soil.

*Marine soil:** soil formed from materials deposited by the waters of oceans and seas, exposed by elevation of the land or by the dessication of the sea.

*Mature soil:** a soil having a profile with a compact highly colloidal dense clay subsoil horizon or a cemented rock-like hardpan horizon; fully weathered mature soil; the end product of weathering under the existing conditions; a climax soil in dynamic equilibrium with its environmental factors.

Maturity: stage of development of soil weathering or soil age, shown by the horizon development of the profile.

*Mechanical analysis:** a laboratory process of separating the soil into groups of grain sizes, used to determine the textural composition of soils.

Micaceous soil: a soil containing visible mica particles, usually derived from acid igneous rock sources.

Mixed origin: soils which have their origin in material from mixed or undetermined rock sources.

Moisture equivalent: a laboratory method of determining the moisture-retaining power of soils. It may be defined as the percentage of water retained by a soil after centrifuging in a standard moisture-equivalent machine under standard conditions. It provides a basis for laboratory comparison of the moisture-holding capacity of different soils. The moisture equivalent has been found to approximate closely the field moisture capacity for medium-textured soils.

*Nut structure:** compact aggregates, more or less rounded in shape, of hard to medium consistence and usually from ½ to 4 centimeters in diameter.

*Parent material:** see horizon C.

*Primary soils:** soils developed through the disintegration and decomposition of rocks in place and the weathering of the resulting debris to true soils with definite horizons of eluviation and illuviation; residual soils.

*Profile or soil profile:** a vertical section of the soil from the surface into the underlying unweathered material.

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* Terms marked (*) are taken from: Shaw, C. F. A glossary of soil terms. American Soil Survey Association Bul. 9:23–58. 1928.

*Recent soil:** a soil having a profile without definite horizons of eluviation or illuviation; relatively unweathered recent or very immature soil. Recent soils usually are secondary soils composed of recently deposited transported materials, there being no evidence of any downward migration of clay, lime, or other material, no evidence of differences in the degree of weathering of the minerals at varying depths, and no indication of any changes in structure of the soil.

*Residual soil:** see primary soil.

*Saline soil:** a soil containing excessive amounts of the neutral or nonalkaline salts, usually chlorides and sulfates.

*Secondary soils:** soils developed through the accumulation and weathering of materials, originating from previously existing soils and from rock debris, that have been eroded from their former locations and redeposited by the transporting agents (alluvial, aeolian, glacial, etc., soils).

Sedimentary origin: soils having their origin in the disintegration and decomposition of material from sedimentary rock sources such as sandstones, shale, and limestone.

*Semimature soil:** a soil having a profile with compact, semicemented horizons with high clay accumulations; strongly weathered soil.

*Soil series:** a grouping of soils having the same character of profile (the same general range in color, structure, consistence, and sequence of horizons), the same general conditions of relief and drainage, and usually a common or similar origin and mode of formation. The name of the series is taken from the region where the first member of that series of soils was discovered, as, for example, Hanford series.

Soil morphology: that part of soil science dealing with the form, arrangement, structure, and other characteristics of the soil mass in its natural condition in place.

*Soil structure:** structure is a term expressing the arrangement of the individual grains and aggregates that make up the soil mass. The structure may refer to the natural arrangement of the soil when in place and undisturbed, or to the soil at any degree of disturbance. See "granular," "nut-structure," "adobe," and "columnar."

*Soil texture:** texture is a term indicating the coarseness or fineness of the soil; the amount or quantity of each of the grain-sized group of particles that constitute the soil. As the soil is usually made up of particles of widely varying size, the textural terms usually express the mass effect or the combined effect of all these grain sizes, but they indicate the predominance (in quantity or in textural effect) of a certain group of grains.

*Soil type:** a soil which throughout the full extent of its occurrence has relatively uniform texture of the surface soil and relatively uniform profile characteristics. It is the unit of soil mapping. The name of the soil type is a combination of series name and the textural grade designation, as, for example, Hanford sandy loam.

Solonetz soil: soil which has a heavy-textured B horizon containing much colloidal clay in a highly dispersed state, and which on drying breaks up into vertical columns (columnar structure), which are usually rounded on the top and may be capped by a grayish layer, usually thin. The transition between the surface

* Terms marked (*) are taken from: Shaw, C. F. A glossary of soil terms. American Soil Survey Association Bul. 9:23–58. 1928.

soil (A horizon) and the heavy-textured columnar layer is very abrupt, both in physical and chemical characteristics. American soil literature has stressed the morphological characteristics of the solonetz rather than its chemical makeup.

In Russian literature, a solonetz soil is defined as having slightly acid surface soil, with the sesquioxides and clay removed from the upper horizon (A) to the B, the absorptive complex partly saturated with sodium, and the soluble salts and carbonates in the lower B_2 or B_3 horizons.

*Subsoil:** see "horizon B."

*Substratum:** see "horizon C."

*Surface soil:** the upper horizon or surface layer of the soil mass, the horizons above horizon A_2. In describing cultivated soils, it usually includes that portion that is modified by plowing and other tillage operations.

*Textural grade:** a classification of soils based on texture alone.

*Transported soil:** soil formed by the consequent or subsequent weathering of materials transported and deposited by some agency such as water, air, or ice; secondary soils.

*Typical profile:** a profile definitely representative of a soil series, the standard of the type or series, as established by careful field study.

*Weathered profile:** a soil profile which has been changed by soil weathering processes; a profile having eluvial and illuvial horizons.

*Young soil:** a soil having a profile with slightly compact subsoil horizons, but with little evidence of clay accumulations; slightly weathered immature soil.

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* Terms marked (*) are taken from: Shaw, C. F. A glossary of soil terms. American Soil Survey Association Bul. 9:23–58. 1928.

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AN INDEX FOR RATING THE AGRICULTURAL VALUE OF SOILS

R. EARL STORIE

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AN INDEX FOR RATING THE AGRICULTURAL VALUE OF SOILS[1]

R. EARL STORIE[2]

INTRODUCTION

The growth and production of plants is dependent very largely upon the soil, and particularly the degree to which it presents conditions favorable for the extension and development of plant roots. On soil that is deep, pervious, relatively uniform in character, and that has fair water-retaining capacity, a very wide range of plants may grow vigorously. On soil with subsoil characteristics that retard the extension of plant roots, growth and development of the plants may likewise be retarded. If the subsoil is only moderately dense and root development only slightly hindered, the growth and production may be good, but if the density of the subsoil reaches that of a claypan, root penetration may be decidedly limited, and if the subsoil is cemented into a true hardpan, or underlaid by hard bedrock, penetration is definitely prevented.

These variations in the character of the soil are directly related to its origin, its mode of formation, and the age or stage of weathering. Recent alluvial deposits are generally deep and pervious, and the profile, or vertical section through the soil mass, shows no variations such as are developed with age. Older soils, which have been exposed to the weathering agents for very long periods of time, have subsoils that have become more dense, until finally they may reach the claypan or hardpan stage. Such soils, which are considered maturely weathered, have approached a condition of equilibrium with the factors that have determined the particular characteristics of their profiles.

The growth of plants on the soil is so closely related to these characteristics of the profile, and the chemical composition of the several horizons of the soil is likewise so closely related to the profile, that it appears possible to rate the soils with the profile characteristics as a base.

[1] Received for publication April 25, 1933.

[2] Assistant Soil Technologist in the Experiment Station.

The index for rating soils as used herein is a numerical expression of the degree to which a particular soil presents conditions favorable for plant growth and crop production under good environmental conditions. In arriving at the relative index of soils three general factors are considered. These are (A) the character of the soil profile; (B) soil texture; and (C) other modifying factors, such as drainage, alkali, and other miscellaneous conditions. Each of these three factors is evaluated on the basis of 100 per cent for the most favorable or ideal condition, with limiting maximum and minimum ratings ascribed to conditions that are less favorable for plant growth.

The information set forth in the various soil-survey publications has been used in developing the index. For a discussion of the soil survey as a source of information, the reader is referred to the Appendix. In studying, mapping, and classifying soils, the character and degree of development of the soil profile, the reaction of the soil mass, the color, the physical composition of the various horizons, the mode of formation and composition of the parent material, the drainage and surface relief, the alkali content, natural cover, etc., are considered in detail.

In arriving at the ratings the experience and judgment of the men engaged in soil-survey work in California has been called upon, and the ratings express the results of their collective studies of the relations of these several conditions of the soil to the growth and production of plants. Obviously, such ratings cannot be final and infallible and may be changed as experience with the use of the soil index indicates.

The index is based on soil conditions alone independent of other physical or economic factors which might determine the desirability of growing certain plants in a given location; hence it cannot be regarded as by itself an index for land evaluation. In the latter, other factors, such as variations in climate, availability of water for irrigation, facilities for transportation and markets, social conditions, and the like, must be included.

Although the soil is only one of the many factors that determine the value of any given area of land surface, it is one that does not readily change and that cannot be materially modified without the expenditure of much effort. Its quality or value is one of the more stable elements that determine *land value*, and an index for rating soils should serve to simplify the work of land classification and evaluation. Other factors, such as the climate, or the quality, quantity, and availability of water for irrigation are likewise natural factors, more or less stable in character, that may be rated in a similar manner, but some physical, economic, and social factors may be too variable or too readily changed to permit of such treatment. Studies of these other factors that influence

or modify land values may show the possibilities of developing indexes for groups of these factors, and by integrating these several indexes, a positive numerical expression of the relative value of any portion of the land surface may result.

METHOD OF RATING

In most endeavors to rate soils on a comparative basis the "score card" method has been used, and the rating determined by *adding* the points credited to each of the soil characteristics or modifying factors. In the index method here presented the rating is obtained by *multiplying* the three factors, A times B times C, thus permitting any one of these to dominate or control the final rating. As an example, a soil may have an excellent profile condition warranting a rating of 100 per cent for factor A, excellent surface-soil conditions giving 100 per cent for factor B, but a bad alkali accumulation that would give a rating of 10 per cent for factor C. Multiplying these three percentage ratings—A × B × C—gives 10 per cent as the index for this soil. The severe alkali accumulation would dominate the quality of this soil, rendering it wholly unproductive for plants and would justify the index of 10 for that soil. On the score-card basis, with possibly 20 or 25 points ascribed to alkali or similar conditions, its worst rating could be only 75 or 80.

The characteristics or conditions included under each of these factors is described in the following chapter, and their bearing on the quality of the soil is discussed.

FACTOR A: CHARACTER OF SOIL PROFILE

Factor A evaluates all the characteristics of the soil profile except the texture of the surface soils. These characteristics, which are determined by the kind of parent material, its mode of formation or accumulation, and the age or degree of modification of the soil material by the weathering agencies of climate, supplemented by vegetation and opposed by erosion and deposition, serve to separate the soils into groups of related individuals that are classed as soil series.

The suitability of soils for plant growth is dependent to a very large extent on the profile characteristics that differentiate the soil series. A series may be defined as "a group of soils having the same character of profile; that is, the same range in color, structure, and general sequence of soil and subsoil horizons, the same general types of relief and drainage, and a common or similar origin and mode of formation."[3] The

[3] Shaw, C. F. A glossary of soil terms. American Soil Survey Association Bul. 9:28–58. 1927.

name of the series implies all the characteristics used to define the soil type except that of surface texture.

For factor A of this index, the soil series of California have been placed in six general groups and a rating given soils of these groups. In each group are series having similar modes of formation, similar sequence of soil and subsoil horizons (i. e., layers), a comparable age, and the same types of relief. The soil series of California officially recognized by the Bureau of Chemistry and Soils of the United States Department of Agriculture and the California Agricultural Experiment Station are listed alphabetically in table 1 with their position in the six groups on the basis of factor A and with certain of their profile characteristics indicated.

The profile characteristics and inclusive ratings for each group under factor A are given in table 2.

Secondary[4] soils are placed in groups I, II, III, and IV; strongly weathered secondary and primary[5] soils having dense clay subsoils developed on consolidated material in group V; and primary soils in group VI. In the following sections characteristics of the soils in each group are described and the profile rating of each explained.

Where soil surveys have been made, the necessary information for this grouping can be obtained from the reports and maps, but if a survey has not been made, then a field examination of the area to be rated is needed in order to determine the profile characteristics.

GROUP I, UNWEATHERED OR ONLY SLIGHTLY WEATHERED SECONDARY SOILS (RECENT OR YOUNG SOILS)

When they have been transported by water, the unweathered secondary soils are commonly referred to as the alluvial, stream-bottom, flood-plain, alluvial-fan, or recent, transported soils. Group I also includes soils deposited or reworked by the action of winds, commonly classed as aeolian or wind-modified soils.

Soils of this group are characteristically more than 6 feet deep and consist of a mass of soil material which has not been modified to any extent by the action of weathering forces, which ultimately bring about a change in the general character of the soil profile. It is because of this that they are spoken of as unweathered soils, in contrast to the moderately weathered soils of group II.

[4] Secondary soils are those formed by the accumulation and weathering of transported materials, originating from previously existing soils and from rock debris, and are often referred to as alluvial, aeolian, or glacial soils, according to the agency which transported them.

[5] Primary soils are those formed by the disintegration and decomposition of rocks in place and the weathering of the resultant debris to true soil.

TABLE 1

Soil Series of California Listed Alphabetically Showing Their Positions in the Six Groups on the Basis of Factor A, and also Showing the Color* of the Surface Soil and the Soil Reaction

Series	Group	Color of surface soil	General reaction
Adelanto	III	Grayish brown	Calcareous subsoils
Agate	V	Brown	Calcareous substratum
Agueda	I	Dark brownish gray	Calcareous throughout
Aiken	VI	Red	Moderately acid
Alamo	IV	Dark gray	Neutral
Aliso	III	Reddish brown	Calcareous subsoils
Altamont	VI	Brown	Calcareous subsoils
Alviso	I	Dark gray	Usually saline
Anderson	I	Yellowish brown	Neutral
Anita	II	Dark brown	Neutral
Antelope	V	Dark gray	Neutral
Antioch	III	Dark brown	Calcareous subsoils
Arbuckle	I	Grayish brown	Neutral
Arnold	VI	Brownish gray	Moderately acid
Arroyo Seco	I	Light brown	Neutral
Atascadero	V	Dark brownish gray	Slightly acid
Ayar	VI	Brown	Calcareous throughout
Ballard	II	Brown	Neutral
Barron	II	Grayish brown	Neutral
Bayside	I	Grayish brown	Moderately acid
Baywood	I	Dark brown	Moderately acid
Bear	I	Reddish brown	Neutral
Bellevista	IV	Light gray	Calcareous throughout
Bieber	V	Dark brown	Neutral
Bishop	I	Dark brownish gray	Calcareous throughout
Botella	I	Dark brownish gray	Neutral
Buntingville	II	Dark grayish brown	Calcareous subsoils
Butte	VI	Brownish gray	Neutral
Cachuma	III	Reddish brown	Neutral
Cajon	I	Light brownish gray	Calcareous throughout
Canby	V	Light gray	Calcareous subsoils
Capay	III	Dark grayish brown	Calcareous subsoils
Carlsbad	VI	Brown	Slightly acid
Carrizo	I	Light gray	Calcareous throughout
Carson	I	Dark gray	Calcareous subsoils
Cayucos	VI	Dark gray to black	Moderately acid..
Centerville	III	Chocolate brown	Calcareous subsoils
Chamise	V	Dark grayish brown	Moderately acid
Chino	II	Dark gray	Calcareous subsoils
Chualar	II	Dark brown	Neutral
Churchill	IV	Grayish brown	Calcareous throughout
Clear Lake	I	Dark gray to black	Calcareous subsoils
Climax	VI	Dark gray to black	Neutral
Coachella	I	Gray	Calcareous throughout
Cole	II	Dark grayish brown	Slightly acid
Columbia	I	Light grayish brown	Neutral
Commatti	II	Gray	Calcareous subsoils
Conejo	I	Dark gray to black	Neutral
Contra Costa	VI	Reddish brown	Neutral

* Color, one of the most obvious of the many soil characteristics, is so closely correlated with the conditions under which the soil has been formed that it often gives considerable information concerning the other characteristics of the soil, such as the organic matter content.

TABLE 1—*(Continued)*

Series	Group	Color of surface soil	General reaction
Coquille	I	Grayish brown, mottled	Acid; saline
Corning	III	Light red	Neutral
Corralitos	II	Brown	Slightly acid
Cuyama	II	Brownish gray	Calcareous throughout
Danville	I	Dark brown	Neutral
Daulton	VI	Reddish brown	Neutral
Delaney	I	Light brownish gray	Neutral
Delano	II	Light reddish brown	Calcareous subsoils
Delhi	I	Light brown	Neutral
Denverton	III	Dark brown	Calcareous subsoils
Diablo	VI	Dark gray to black	Calcareous subsoils
Diamond Springs	VI	Grayish yellow	Slightly acid
Docas	II	Brownish gray	Calcareous throughout
Domino	IV	Light brownish gray	Calcareous throughout
Dublin	I	Dark gray to black	Neutral
Ducor	II	Dark chocolate brown	Calcareous subsoils
Dunnigan	III	Brownish gray	Calcareous subsoils
Egbert	I	Dark gray	Moderately acid
Elder	I	Dark brownish gray	Calcareous subsoils
Elkhorn	II	Brown	Slightly acid
Elna	IV	Light gray	Calcareous throughout
Empire	III	Reddish brown	Strongly acid
Encina	VI	Dark brown	Slightly acid
Escondido	VI	Yellowish brown	Neutral
Esparto	II	Light brown	Slightly acid
Exeter	III	Reddish brown	Neutral
Fallbrook	VI	Reddish brown	Neutral
Fancher	IV	Reddish brown	Neutral
Farwell	I	Light chocolate brown	Calcareous subsoils
Feather	I	Brown	Neutral
Ferndale	I	Brownish gray	Moderately acid
Foster	I	Dark brownish gray	Calcareous throughout
Fresno	IV	Brownish gray	Calcareous; alkaline
Fullerton	II	Brown	Neutral
Galveston	I	Dark gray	Usually saline
Gleason	VI	Dark brown	Neutral
Garey	II	Light reddish brown	Moderately acid
Gazelle	IV	Dark brownish gray	Calcareous throughout
Gila	I	Light purplish brown	Calcareous throughout
Gloria	IV	Brownish red	Neutral
Goldridge	VI	Yellowish gray	Moderately acid
Gould	V	Reddish brown	Neutral
Greenfield	I	Brown	Neutral
Gridley	III	Brown	Neutral
Hames	III	Brown	Slightly acid
Hanford	I	Light brown	Neutral
Hartley	III	Light brownish red	Neutral
Hesperia	I	Light brown	Calcareous subsoils
Holcomb	III	Light brown	Moderately acid
Holland	VI	Brown	Slightly acid
Holtville	I	Light purplish gray	Calcareous throughout
Honcut	I	Reddish brown	Neutral
Hovey	II	Dark gray to black	Calcareous subsoils
Huerhuero	III	Light grayish brown	Calcareous subsoils
Hugo	VI	Yellowish brown	Moderately acid
Imperial	I	Light purplish gray	Calcareous, alkaline
Indio	I	Brownish gray	Calcareous throughout

TABLE 1—*(Continued)*

Series	Group	Color of surface soil	General reaction
Johnsonville	II	Brown	Calcareous subsoils
Keefers	III	Brownish red	Slightly acid
Kettleman	VI	Gray	Calcareous throughout
Kimball	III	Brownish red	Neutral
Kirkwood	III	Dark gray	Neutral
Klamath	III	Dark gray	Neutral
Kneeland	V	Dark grayish brown	Moderately acid
Konokti	VI	Brown	Slightly acid
Laguna	I	Light brownish gray	Neutral
Lahontan	II	Light gray	Calcareous; alkaline
Landlow	V	Brown to dark brown	Calcareous subsoils
Las Flores	V	Light gray	Slightly acid
Las Posas	VI	Brownish red	Neutral
Lassen	VI	Dark brown	Calcareous subsoils
Lewis	III	Brownish gray	Usually alkaline
Lindsey	II	Dark gray	Calcareous subsoils
Linne	VI	Dark brownish gray	Calcareous throughout
Livermore	II	Dark grayish brown	Neutral
Lockwood	III	Grayish brown	Neutral
Los Angeles	VI	Light brown	Calcareous subsoils
Los Osos	VI	Dark brown	Moderately acid
Lynndyl	II	Light grayish brown	Calcareous throughout
Madera	IV	Brown	Neutral
Manzanita	III	Brownish red	Moderately acid
Marcuse	III	Dark gray	Usually alkaline
Maricopa	II	Reddish brown	Neutral
Marina	I	Brown	Slightly acid
Mariposa	VI	Brownish yellow	Moderately acid
Marvin	II	Light brown	Calcareous subsoils
Marysville	IV	Reddish brown	Neutral
Maywood	I	Yellowish brown	Neutral
McClusky	III	Dark grayish brown	Moderately acid
Media	VI	Brown	Neutral
Melbourne	VI	Brown	Moderately acid
Meloland	I	Light brownish gray	Calcareous throughout
Merced	III	Dark gray to black	Calcareous subsoils
Merriam	III	Light reddish brown	Calcareous subsoils
Metz	I	Light brown	Calcareous throughout
Mocho	I	Brown	Calcareous throughout
Modoc	II	Dark brown	Neutral
Mojave	III	Reddish brown	Calcareous throughout
Mono	IV	Light brownish gray	Calcareous throughout
Monserate	V	Brown	Calcareous subsoils
Montague	IV	Dark grayish brown	Calcareous subsoils
Monterey	VI	Reddish brown	Moderately acid
Montezuma	III	Dark gray to black	Calcareous subsoils
Moro Cojo	VI	Reddish brown	Moderately acid
Nacimiento	VI	Brownish gray	Calcareous throughout
Niland	II	Light brownish gray	Calcareous; alkaline
Nord	I	Grayish brown	Calcareous throughout
Norman	III	Dark brown	Often alkaline
Oakdale	I	Grayish brown	Neutral
Oakley	I	Light brown	Slightly acid
Ojai	III	Pale yellow	Neutral
Olcott	III	Brown	Neutral
Olivenhain	V	Light brown	Slightly acid
Olympic	VI	Dark brown	Moderately acid

TABLE 1—*(Continued)*

Series	Group	Color of surface soil	General reaction
Orland	II	Light grayish brown	Neutral
Oxnard	I	Brown	Calcareous subsoils
Pajaro	I	Brown	Neutral
Panoche	I	Brownish gray	Calcareous throughout
Pentz	VI	Dark grayish brown	Neutral
Pinole	III	Yellowish brown	Neutral
Pit	I	Dark gray to black	Neutral
Placentia	III	Brownish red	Neutral
Pleasanton	II	Brown	Neutral
Pond	II	Brownish gray	Calcareous; alkaline
Poplar	II	Light brown	Neutral
Porterville	II	Chocolate brown	Calcareous subsoils
Preston	I	Light grayish brown	Slightly calcareous
Ramada	I	Light yellowish brown	Neutral
Ramona	II	Reddish brown	Neutral
Redding	IV	Brownish red	Strongly acid
Rhonerville	II	Dark brownish gray	Strongly acid
Rincon	II	Brown	Neutral
Rocklyn	IV	Brownish red	Slightly acid
Rosamond	II	Light grayish brown	Calcareous throughout
Rositas	I	Light brownish gray	Calcareous throughout
Sacramento	II	Dark gray to black	Slightly calcareous subsoils
Salinas	II	Dark brownish gray	Calcareous subsoils
Salsipuedes	II	Dark brown	Slightly acid
San Gabriel	I	Light brown	Neutral
San Joaquin	IV	Brownish red	Slightly acid
San Marcos	II	Dark brownish gray	Calcareous subsoils
San Ysidro	II	Brownish gray	Neutral
Santa Cruz	VI	Reddish brown	Moderately acid
Santa Lucia	VI	Dark grayish brown	Neutral
Santa Rita	II	Grayish brown	Calcareous throughout
Santa Ynez	III	Dark grayish brown	Neutral
Santiago	II	Dark gray	Calcareous subsoils
Shasta	II	Light brownish gray	Neutral
Shedd	VI	Gray	Calcareous throughout
Sheridan	VI	Dark gray	Neutral
Sierra	VI	Brownish red	Moderately acid
Siskiyou	VI	Brownish gray	Neutral
Sites	VI	Brownish red	Moderately acid
Solano	III	Dark brownish gray	Calcareous subsoils
Soledad	II	Brown	Neutral
Sorrento	I	Light brown	Calcareous subsoils
Stacy	I	Light brown	Calcareous throughout
Standish	V	Grayish brown	Calcareous throughout
Stockpen	III	Light gray	Calcareous subsoils
Stockton	V	Dark gray to black	Calcareous subsoils
Sunol	II	Reddish brown	Neutral
Sunrise	IV	Light reddish brown	Calcareous throughout
Superstition	I	Gray	Calcareous throughout
Surprise	I	Dark brown	Neutral
Sutter	I	Light brownish gray	Neutral
Tangair	IV	Brownish gray	Moderately acid
Tassajero	I	Brown	Neutral
Tehama	II	Light yellowish brown	Neutral
Tierra	V	Dark grayish brown	Moderately acid
Tijeras	V	Light reddish brown	Calcareous throughout
Tujunga	I	Light brownish gray	Neutral

TABLE 1—*(Concluded)*

Series	Group	Color of surface soil	General reaction
Tulare	II	Light gray	Calcareous throughout
Tuscan	V	Brownish red	Neutral
Ulmar	V	Grayish brown	Calcareous subsoils
Underwood	VI	Reddish brown	Calcareous subsoils
Vallecitos	VI	Reddish brown	Neutral
Vina	I	Light chocolate brown	Neutral
Vista	VI	Brown	Neutral
Wapato	I	Brown, mottled	Strongly acid
Watsonville	VI	Dark brown	Moderately acid
Westport	II	Dark brownish gray	Moderately acid
Whitney	VI	Reddish brown	Neutral
Willits	II	Grayish brown	Moderately acid
Willows	I	Reddish brown	Neutral
Woodrow	I	Brownish gray	Calcareous; alkaline
Wyman	II	Reddish brown	Neutral
Yolo	I	Brown	Neutral
Ysidora	VI	Reddish brown	Neutral
Zaca	VI	Dark gray to black	Calcareous throughout

TABLE 2

RATING OF SOILS ON THE BASIS OF PROFILE CHARACTERISTICS

Group	Group number	Description	Surface relief	Profile rating (factor A) in per cent
Unweathered or slightly weathered secondary	I	Loose and friable material 6 feet or more deep	Flat or gently sloping	95–100
Moderately weathered secondary soils	II	Deep but have compact subsoils and slight to moderate accumulation of clay	Terraces, benches or valley floors	80–95
Strongly weathered secondary soils	III	Dense clay subsoils, loose unconsolidated parent material	Terraces	40–80
Maturely weathered secondary soils	IV	Hardpan soils, often have fairly dense clay subsoils	Flat terraces, valley floors, often hogwallow surface	5–60
Strongly weathered soils having dense clay subsoils, developed on consolidated material	V	Coastal plain soils	High eroded terraces	20–40
Primary soils (residual)	VI	Formed in place from decomposition and disintegration of underlying bedrock	Hilly, rolling or mountainous	20–70

The most valuable agricultural soils of California fall in this group; they occur on the flood plains and alluvial fans of many of the California streams. They are especially valuable for orchards, vegetables, and deep-rooted field crops. Yields on many of the medium-textured alluvial soils have remained consistently high for a long period without recourse to fertilization. The crop yields are consistently higher than on soils of the other groups. These soils, providing conditions favorable for the growth of almost any crop plants, have been given a factor-A rating of 95 to 100 per cent.

TYPE Yolo fine sandy loam LOCATION One mile southwest of Davis Calif
RELIEF Alluvial fan ELEVATION 50 feet DRAINAGE Well drained
RAINFALL 18 inches NATIVE VEGETATION Grasses USE Wide use
ORIGIN Alluvial from sedimentary rock sources DEVELOPMENT OF PROFILE Recent soil
REMARKS Profile rating of 100.

PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION	MISCELLANEOUS ROOTS, STONES, CONCRETIONS, PERMEABILITY, ETC.
0–12	Brown to light brown	fine sandy loam	granular	loose and friable	neutral 7.0	considerable organic material and roots
12–24	light brown	variable textured	structureless	friable	neutral 7.0	easily penetrated by roots and moisture
24–36						
36–48						
48–60						

Fig. 1.—Soil description and profile of Yolo fine sandy loam. This type of form is of use in reporting and showing the characteristics of a soil by horizons.

Variation in texture of the surface soils is rated under factor B and discussed in a separate section. Any conditions unfavorable to plant growth, such as gravelly subsoil layers, injurious amounts of alkali, high acidity, or poor drainage conditions that may occur are rated under factor C.

The Hanford, Yolo, Columbia, and Honcut are extensively developed soil series of this group. The fact that some of the best crop yields of the state are secured on these soils indicates the soundness of the high rating given them. Figure 1 gives a typical profile of a Yolo fine sandy loam which serves to illustrate the general depth and pervious nature of the profiles of soils in group I.

GROUP II, MODERATELY WEATHERED SECONDARY SOILS (IMMATURE SECONDARY SOILS)

Group II consists of water-laid or wind-laid deposits which have been subjected to weathering for a sufficient period to develop subsoil characteristics very distinct from those of the recent or unweathered group. These have profiles with clearly evident clay accumulations in the moderately compact subsoil layers, while many of the soils also have accumulations of lime in the subsoil. Subsoils are permeable to moisture and roots, although not to the same degree as the younger soils of group I.

TYPE Ramona sandy loam LOCATION El Cajon Valley - San Diego County
RELIEF Sloping Terrace ELEVATION 500 feet DRAINAGE Well drained
RAINFALL 12 inches NATIVE VEGETATION Grass - brush USE Wide use
ORIGIN Secondary from granite DEVELOPMENT OF PROFILE Immaturely weathered
REMARKS Occupies a terrace slightly higher in elevation than the recent alluvial soils. Profile rating of 90.

PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION	MISCELLANEOUS ROOTS, STONES, CONCRETIONS, PERMEABILITY, ETC.
0–12	Brown	sandy loam	medium granular	dries out fairly hard	neutral 7.0	permeable
12–24	Brown to reddish brown	gritty loam	coarse granular	slightly compact, fairly hard when dry.	neutral 7.0	permeable
24–36	reddish brown	sandy clay loam	irregular shaped clods when broken up dry.	moderately compact	neutral 7.0 - 7.3	considerable colloidal staining on surface of clods. permeability to moisture somewhat retarded.
36–48						
48–60	pale reddish brown	sandy loam	amorphous	slightly compact.	neutral 7.0	

Fig. 2.—Profile description of Ramona sandy loam, San Diego County, California, illustrative of the general characteristics of the soils in group II (moderately weathered secondary soils), having compact subsoil layers with clay accumulations.

This is evidenced by the somewhat slower penetration of irrigation water. The parent material below the subsoil is usually permeable to a depth of 6 feet or more. These soils usually occur on smooth terraces and mesas, lower benches, and in some cases on typical alluvial-fan surfaces, usually being slightly higher in elevation than those of group I. Many of the soil series in this group occur on terraces which have been slightly eroded so that the topography is somewhat irregular, especially on the borders.

These are good soils, although of less value than those of group I, since they are older, have a moderate subsoil compaction and accumulation of clay, which retards the penetration of moisture, and may have a more

irregular surface, which lessens their value for irrigated crops. They are given a factor-A rating of 80–95 per cent.

Soils of the Ramona series are the best known in this group. A typical profile description of Ramona sandy loam is given in figure 2.

GROUP III, STRONGLY WEATHERED SECONDARY SOILS WITH DENSE CLAY SUBSOILS (SEMIMATURE SECONDARY SOILS)

The soils of group III are characterized by a very heavy, dense, plastic clay subsoil layer that breaks up when dry into very hard dense structural aggregates. These are semimaturely weathered soils. They are of

TYPE Antioch fine sandy loam LOCATION Eastern Solano County
RELIEF Flat terrace ELEVATION 40 feet DRAINAGE Subdrainage restricted
RAINFALL 18 inches NATIVE VEGETATION Grass USE Pasture
ORIGIN Mixed material DEVELOPMENT OF PROFILE Semimature
REMARKS Profile rating of 60

PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION	MISCELLANEOUS ROOTS, STONES, CONCRETIONS, PERMEABILITY, ETC.
0–12	Dull grayish brown	fine sandy loam	slightly granular	friable, loose	slightly acid pH 6.2	fairly well filled with roots.
12–24	light gray	sandy loam	single grained	loose	pH 6.5	
24–36	Dark grayish brown	clay	breaks up into columns when dry	very compact	neutral to slightly basic	colloidal glazing
36–48	Dark grayish brown	clay loam or clay	cubical when dry	compact	Basic. Calcareous	lime occurs in nodules and seams
48–60	Yellowish brown	loam	cloddy when broken	fairly compact	neutral to slightly basic	

Fig. 3.—Profile description of Antioch fine sandy loam from Solano County, California; claypan soil of group III.

alluvial or marine origin, but have been materially changed in chemical and physical make-up since they were deposited. All have a leached surface usually of sandy texture, low in available plant food, and normally moderately acid in reaction. There is usually an abrupt change from the sandier surface layers to the heavy, dense clay subsoils. The downward movement of water is markedly retarded and the soils become temporarily water-logged after heavy rains. The heavy subsoils are underlaid by pervious parent materials penetrable by roots and water. In some cases these parent materials are loose soil, while in others they are fairly compact, but in all cases they are penetrable to a depth of 6 feet or more.

These soils occupy terraces or benches which are often somewhat eroded. They are of common occurrence in most of the California valleys and along the coast line of central and southern California.

Their value is limited by the heavy subsoil layer and often to some extent by the eroded surface, which makes them difficult to irrigate and cultivate. They are given a rating of 40–80 per cent. Within these limits the rating will depend on the depth to the clay layer and the general surface conditions. Soils occurring under higher rainfall, such as the

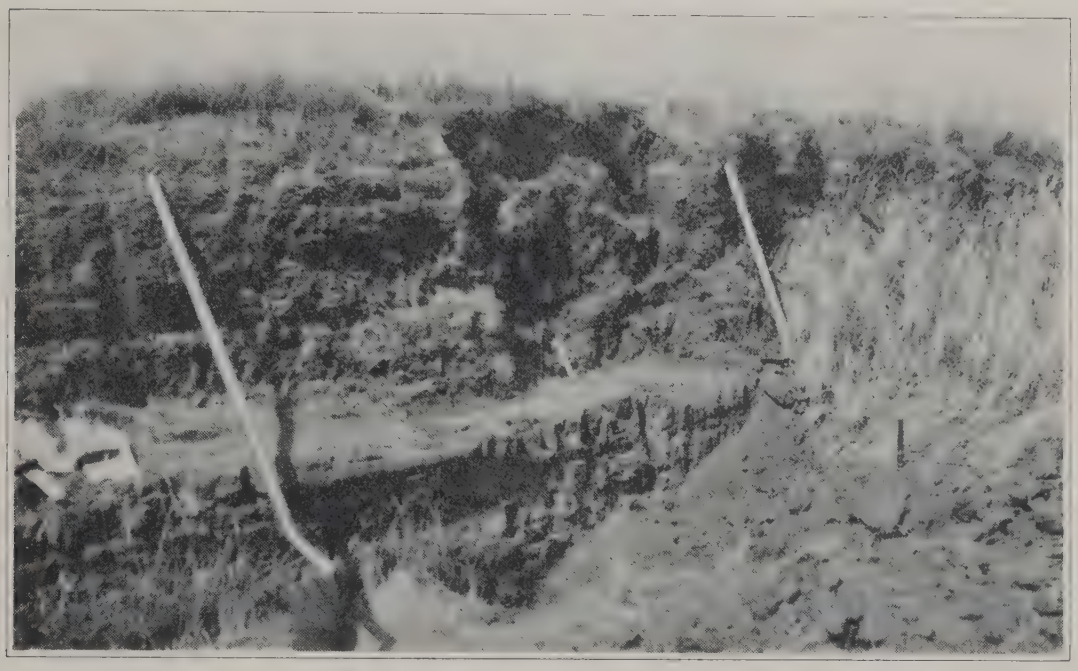


Fig. 4.—Profile of San Joaquin sandy loam (hardpan soil, group IV), San Joaquin Valley, California. The hardpan layer is about 2 feet thick, with about 3 feet of soil material overlying the hardpan. (Photograph by C. F. Shaw.)

Antioch series, have surface soils as much as 20 to 24 inches in thickness, while the southern California soils of similar character (such as the Huerhuero series), but located where the rainfall is much less, have much shallower surface soils. Figure 3 gives details of a profile of the Antioch fine sandy loam located near Fairfield. This soil is given a higher rating than the Huerhuero because of its depth of surface soil and the level surface of the terrace on which it occurs.

GROUP IV, MATURELY WEATHERED SECONDARY SOILS WITH HARDPAN

The soils with hardpan appear to have reached a mature age or stage of weathering, and are characterized by the cemented, rock-like subsoil horizon (fig. 4) that has been formed as a direct result of the soil-weathering process. True hardpans do not soften when saturated with

water, thus being distinguished from certain dense clay subsoils, which are often erroneously referred to as hardpan layers.

True hardpan soils occur under arid or semiarid climatic conditions, and the depth to the hardpan layer is usually closely correlated with the depth of the annual penetration of rainfall. A dense clay layer normally lies just above the hardpan. Where the hardpan is continuous and unbroken, drainage conditions are poor and the surface soil becomes saturated after heavy rains. They usually occur on sloping terraces or on valley floors and often have a "hogwallow" surface of small mounds and depressions (fig. 5). Some areas have suffered considerable erosion.



Fig. 5.—Natural mounds or "hogwallow" surface of San Joaquin sandy loam, Kern County, California. (Photograph by C. F. Shaw.)

The largest areas of hardpan soils lie in the Great Valley of California, especially in the San Joaquin. They are also scattered throughout the valleys of southern California. They occupy a total of over three million acres in the state.

Considerable discussion has developed over the subject of the utilization of hardpan soils and the extent to which the undesirable features, such as the limited depth of the soil material overlying the hardpan and the thickness and hardness of the hardpan, may reduce the value of such soils. The rooting zone of plants is limited when the hardpan is close to the surface. The moisture capacity is limited by the shallow depth of soil above the hardpan; irrigation water must be applied frequently and in small amounts, or saturation and poor drainage will result; and other difficulties arise owing to the limited mass of soil material. The organic content of hardpan soils is usually low, and the clay fractions of such character that the soils have a tendency to bake hard on drying, thus rendering them more difficult to handle. The undulating hogwallow surface configuration of such lands also renders them difficult to

prepare for irrigation. When they are leveled, it is noted that crops respond better in the filled places than they do on the areas where soil has been removed.

The following ratings are based on the depth to hardpan:

	Rating, in per cent
Hardpan less than 1 foot	5–10
1 to 2 feet	10–20
2 to 3 feet	20–30
3 to 4 feet	30–40
4 to 6 feet	40–60

These figures should be raised in certain instances where the hardpan is soft or broken or occurs in thin plates. A typical profile of San Joaquin sandy loam, a red "iron" hardpan soil, is given in figure 6.

TYPE San Joaquin sandy loam LOCATION Near Chowchilla - San Joaquin Valley
RELIEF Slopy terrace Slightly low ELEVATION 250 feet DRAINAGE Subdrainage restricted
RAINFALL 11 inches NATIVE VEGETATION Grass USE Pasture
ORIGIN Secondary from granite DEVELOPMENT OF PROFILE Naturely weathered
REMARKS "Red iron" hardpan soil
Profile rating of 25.

PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION	MISCELLANEOUS ROOTS, STONES, CONCRETIONS, PERMEABILITY, ETC.
0	Reddish brown	sandy loam	breaks up into small clods	loose when moist, hard when dry	moderately acid	permeable
12	reddish brown	loam	cloddy	slightly compact	neutral	permeable
24	brownish red	clay	block	very compact	slightly basic	clay retards penetration of moisture and roots
36	Brown to red		massive	Very dense	basic	Iron and silicia cemented hardpan Impermeable
48	Brown	variable textured	structureless	loose to fairly compact	basic	permeable
60						

Fig. 6.—Profile description of San Joaquin sandy loam, a typical hardpan soil of group IV.

GROUP V, STRONGLY WEATHERED SOILS WITH DENSE CLAY SUBSOILS RESTING ON CONSOLIDATED MATERIALS

Soils of group V are common along the coastal plain of California. Their value is relatively low because of the leached surface, the heavy-textured subsoil, and particularly because of the hardpan-like substratum which, although composed of sediments, is essentially rock-like in its nature (fig. 7). Surface soils are normally somewhat acid in reaction. There is usually an abrupt change from the surface layer to the heavy dense clay subsoil, and after heavy rains these soils become temporarily water-logged.

With two exceptions, the Stockton and Landlow, all the soil series so far mapped occur on high terraces which have been subjected to considerable erosion. The Stockton and Landlow soils occur on flat, poorly drained plains, and instead of being sandy have heavy-textured surface soils.

In this group the surface soils overlying the clay subsoils are usually less than 15 inches in thickness, and the clay subsoil varies from 10 to 24 inches in thickness. Thus the consolidated substratum is found at from 15 to 48 inches below the surface.



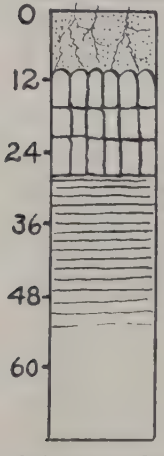
Fig. 7.—Profile of Olivenhain loamy fine sand from San Diego County, California. Note the sandy surface soil lacking structure, the heavy-textured, dense subsoil, which breaks up into columnar structure when dry, and the massive consolidated substratum. This is a typical soil of group V. (From Bul. 552.)

In rating the soils of this group for factor A the points considered are the depth to the clay layer, the depth to the substratum, the nature of the substratum, and the surface relief. The range in rating is from 20 to 40 per cent. Surface texture and other factors are handled under factors B and C.

Soils of the Olivenhain, Tierra, and Las Flores series, which are typical of this group, have similar sequence of horizons, and differ mainly in color. A profile of Olivenhain loamy fine sand from the coastal plain of San Diego County is given in figure 8. The factor-A rating of this soil is 25 per cent.

TYPE Olivenhain loamy fine sand LOCATION Thirty miles north of San Diego
RELIEF High eroded terrace ELEVATION 400 ft. DRAINAGE Subdrainage restricted
RAINFALL 6–12" NATIVE VEGETATION Short brush USE Shallow rooted crops
ORIGIN Marine terrace DEVELOPMENT OF PROFILE Semi mature
REMARKS

Profile rating of 25



PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION	MISCELLANEOUS ROOTS, STONES, CONCRETIONS, PERMEABILITY, ETC.
0–12	Brown	loamy fine sand	slightly granular	loose	pH 6.2 slightly acid	few roots
12–24	Dark brown	clay	Breaks up into columns when dry	very compact	7.2 slightly basic	Roots do not penetrate this layer very readily. High content of colloidal clay.
36–60	Brown to light gray.	variable textured	massive	consolidated	7.0	Saline substratum

Fig. 8.—Profile description of Olivenhain loamy fine sand, typical of coastal plain soils having dense clay subsoils (group V).

GROUP VI, SOILS DEVELOPED ON BEDROCK (PRIMARY OR RESIDUAL SOILS)

Soils of group VI have been formed by the disintegration and decomposition of the underlying parent bedrock (fig. 9). Shaw[6] has termed them primary soils. They are also referred to in soil literature as residual soils. They are the hill lands of California, occupying a topography that is rolling, hilly, or mountainous (fig. 13).

Their characteristics are determined to a large extent by the character of the parent bedrock and the rainfall of the region in which they occur. Often they are shallow and stony. These factors, together with the topography and surface configuration, determine their value. Because of their slope, they are more difficult to farm than the terrace and valley lands. The steep slopes have a tendency to erode badly, especially when cultivated. The normal progress of erosion is the main factor that keeps most primary soils from reaching a mature stage of soil weathering. Most of the primary soils have a moderate accumulation of clay in the subsoils as a result of soil weathering, but not nearly so much as exists in soils of groups III, IV, or V. Usually the upper portion of the underlying parent bedrock has been softened by weathering action so that roots and moisture have an opportunity to work their way down into the bedrock through cracks and crevices for some distance.

[6] Shaw, C. F. A definition of terms used in soil literature. Intntl. Congr. Soil Sci. Proc. 5:38–64. 1928.



Fig. 9.—Profiles of shallow primary soil (group VI), Sierra Nevada foothill district.

TYPE Holland sandy loam LOCATION Sierra Nevada foothills near Newcastle
RELIEF Hilly ELEVATION 700 feet DRAINAGE Well drained
RAINFALL 30 inches NATIVE VEGETATION Brush - oak USE Plums and peaches
ORIGIN Primary soil from granite DEVELOPMENT OF PROFILE Immature
REMARKS
Profile rating of 65

PROFILE	COLOR	TEXTURE	STRUCTURE	CONSISTENCE AND DENSITY	REACTION	MISCELLANEOUS ROOTS, STONES, CONCRETIONS, PERMEABILITY, ETC.
0–12	Light grayish brown	sandy loam	coarse granular	friable, loose	moderately acid	permeated by roots
12–24	Light brown	sandy loam	breaks up into small clods	slightly compact	moderately acid	permeated by roots
24–36	Brown	gritty loam	medium sized clods	compact when dry	moderately acid	some colloidal glazing
36–48						Disintegrating granitic bedrock.
48–60						

Fig. 10.—Profile description of Holland sandy loam in the Sierra Nevada foothills. This is a primary or residual soil of group VI.

Considerable variation is encountered in depth and stone content, and such variations are considered in rating these soils. Typically, primary soils are well drained and contain no alkali so that these factors do not have to be considered under factor C.

Texture of the surface soil is largely governed by the type of parent bedrock. Coarsely crystalline rocks, such as granites, usually give rise to sandy soils, while the finer-textured rocks, such as the andesites, weather into clay loam types.

Some of the better-known primary soils are those of the Holland, Sierra, and Aiken series of the Sierra-Nevada foothills. The Aiken is the very red primary soil derived mainly from andesitic parent bedrock, while the other two are brown and red granitic soils. A profile description of a Holland sandy loam of the Sierra-Nevada foothill district is given in figure 10.

The ratings given the primary soils are based on the depth of soil material overlying bedrock, as follows:

	Rating, in per cent
Less than 1 foot	20–25
1 to 2 feet	25–40
2 to 3 feet	40–60
over 3 feet	60–70

FACTOR B: TEXTURE OF SURFACE SOIL

Factor B rates the soil on the basis of the characteristics of the surface soils, independent of the subsoils. It is a rating of the soil textures and those other characteristics that are more or less dependent on texture, such as the consistence (hardness or softness) of the soil aggregates, the porosity of the soil mass, the permeability to water, the tilth (response to tillage operations), and similar characteristics or reactions. These are so dominated by texture that a rating on the textural basis will also express the general effect of these features.

Textural grades, designated in popular terms such as sandy loam, loam, and clay loam, express the mass effect of the amounts of different-sized grains that constitute the soil. The physical composition of a soil can be accurately determined by a mechanical analysis which separates the soil into grain-sized groups. The limits of the amounts of the grain-sized groups present in any textural grade have been definitely established.

TABLE 3

TEXTURAL GRADES OF SOILS*

Grade	Definition†	Obvious characteristics
Coarse sand	Contains less than 20 per cent silt and clay, and more than 35 per cent fine gravel and coarse sand grain sizes, and less than 50 per cent any other grade.	
Sand	Contains less than 20 per cent silt and clay, and more than 35 per cent fine gravel and coarse sand and medium sand, and less than 50 per cent fine sand.	Sands are loose and granular. The individual grains can readily be seen and felt. Squeezed in the hand when dry the material will fall apart when the pressure is released. Squeezed when moist, it will form a cast but will crumble when touched, although fine sand and very fine sand have a certain amount of cohesion when moist.
Fine sand	Contains less than 20 per cent silt and clay, and more than 50 per cent fine sand, and less than 25 per cent fine gravel and coarse and medium sand.	
Very fine sand	Contains less than 20 per cent silt and clay, and more than 50 per cent very fine sand, and less than 25 per cent fine gravel and coarse and medium sand.	
Sandy loam	Contains between 20 and 50 per cent silt and clay, and more than 25 per cent fine gravel and coarse and medium sand, and less than 35 per cent fine or very fine sand.	Contains much sand but which has enough silt and clay for coherence, gritty feel; sand grains can be seen. Squeezed when dry will form a cast which will readily fall apart, but if squeezed when moist a cast can be formed that will bear careful handling without breaking. Classed as coarse, medium, fine or very fine sandy loam, depending on the proportion of the different-sized particles that are present.
Fine sandy loam	Contains between 20 and 50 per cent silt and clay, and more than 50 per cent fine sand, and less than 25 per cent fine gravel and coarse and medium sand.	
Very fine sandy loam	Contains between 20 and 50 per cent silt and clay, and more than 35 per cent very fine sand, and less than 25 per cent fine gravel and coarse and medium sand.	
Loam	Contains more than 50 per cent total silt and clay, and less than 20 per cent clay, from 30 to 50 per cent silt, and from 30 to 50 per cent sands.	Even mixture of different grades of sand, and of silt and of clay. Mellow, of somewhat gritty feel, yet fairly smooth and rather plastic. Squeezed when dry it will form a cast that will bear careful handling, while the cast formed by squeezing the moist soil can be handled rather freely without breaking.

* For ratings see table 4, page 38.

† The grades are defined on the basis of the amount of the several grain-sized groups of particles found in them upon mechanical analysis. For the sizes of the soil-particle groups see footnote 7, page 24.

TABLE 3—*(Concluded)*

Grade	Definition	Obvious characteristics
Silt loam	Contains more than 50 per cent total silt and clay, and less than 20 per cent clay, more than 50 per cent silt, and less than 50 per cent sands.	Moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called "silt." When dry it may appear cloddy but the lumps can readily be broken, and when pulverized it feels soft and floury. Either wet or dry the soil will form a cast that can be freely handled without breaking. If squeezed between the thumb and finger it will not "ribbon," but will give a broken appearance.
Clay loam	Contains more than 50 per cent total silt and clay, and 20 to 30 per cent clay, and less than 50 per cent silt or sand.	A clay loam in the field is dense and compact, and breaks into clods or lumps, which when dry are hard to break. When the moist soil is pinched between the thumb and finger it will form a thin "ribbon" that will break readily, barely sustaining its own weight. Moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand it does not crumble readily but tends to work into a heavy compact mass.
Silty clay loam	Contains more than 50 per cent total silt and clay, and 20 to 30 per cent clay, more than 50 per cent silt, and less than 30 per cent sand.	Silty clay loam contains more of the particles termed "silt" so that the soil is less plastic than the clay loam.
Clay	Contains more than 30 per cent clay, and less than 50 per cent silt or sands.	Dense and compact, forming very hard lumps or clods when dry. Composed of very fine particles which when wet stick together to make a very putty-like and plastic mass. When the moist soil is pinched out between the thumb and fingers it will form a long flexible "ribbon."
Silty clay	Contains more than 30 per cent clay, more than 50 per cent silt, and less than 20 per cent sands.	Silty clay contains more of the particles termed "silt" so that the soils break down more readily than a clay.
Adobe clay or clay adobe	Contains more than 30 per cent clay, particularly the ultra or colloidal-clay particles, and less than 50 per cent silt or sands.	In addition to characteristics of clay, adobe clays contract on drying, producing large cracks and blocks. Secondary cracking may cause them to break into smaller fragments. The term "adobe" alone, refers to this structure produced by shrinkage on drying.

The various textural grades of soils are listed in table 3, with the amounts of the grain-sized groups (determined by mechanical analysis),[7] and some of the obvious physical characteristics of the various soil textures. The major textural grades give very characteristic responses when rubbed between the thumb and fingers, and when kneaded and molded while wet. With practice, the textural grade of a soil can be approximated by this hand test, which aids in determining the texture when soil maps are not available.

Texture or physical composition controls, to a large degree, the water-holding capacity, permeability to moisture, ease of tillage, plasticity, the stickiness of the soil when wet, and the friability and hardness when dry. Soils having ideal conditions from the textural standpoint as reflected in these physical characteristics are rated at 100 per cent in factor B. Soils having less favorable textures are rated according to their relative order. Soils with a large percentage of sand or gravel are relatively low in the plant nutrients and do not retain moisture so well as do those of finer texture. At the other extreme heavy-textured soils, those having a high percentage of clay particles, are more difficult to handle and have other disadvantages, although they may contain a maximum of moisture and plant nutrients.

It must be borne in mind that the ratings on soil texture are on a *relative basis* and can be varied to some degree as conditions may warrant.

MEDIUM-TEXTURED SOILS	Rating, in per cent
Fine sandy loam	100
Loam	100
Silt loam	100
Sandy loam	95
Coarse sandy loam	90
Loamy sand	80

The medium-textured soils are given the highest rating since they do not contain an excess of either the sand or the clay, have a medium-soft consistence, take water readily yet have a good water-holding capacity, are friable and easy to cultivate, do not readily puddle or form clods, and in general are most easily maintained in a condition of good tilth.

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[7] Eight grain-sized groups have been adopted by the United States Department of Agriculture with the effective diameter of the particles as indicated below:

Diameter in millimeters	Name of size group	
2.0 – 1.0	fine gravel	
1.0 – 0.5	coarse sand	
0.5 – 0.25	sand	
0.25 – 0.10	fine sand	
0.10 – 0.05	very fine sand	
0.05 – 0.005	silt	
0.005 – 0.002	coarse clay	clay
less than 0.002	ultra or colloidal clay	clay

The properties of silty clay and clay soils are largely governed by the character of the clay particles that make up from 30 to 60 per cent of the soil mass. Often a large proportion of the clay particles are of the ultra-clay or colloidal-clay size and exhibit the physical properties of colloids.

Clay soils are cold and sticky when wet, and very hard when dry. The high clay or colloidal content impedes the movement of water, causing water-logged conditions in wet weather and lack of available moisture during the dry season. When dry, they shrink and crack, frequently breaking into large, hard blocks with wide cracks between, giving the structure known as "adobe clays." As a result they are not so desirable as the lighter-textured soils. They are best adapted to crops, such as grain and rice, for which heavy machinery is needed.

Most clays are improved by the addition of lime or other flocculating materials, which cause the soil to form aggregates with definite structural properties, and results in a decrease in the plasticity and hardness of the mass. This materially increases the ease of tillage. On the other hand, certain of the alkali salts exert a deflocculating effect on the soil mass, making it less pervious and more difficult to till. Organic matter acts very much in the same way as lime on clay soils, but the amount has to be high and frequently applied in order to make much improvement in the physical condition.

Clays generally are high in plant nutrients, but physical factors such as plasticity, penetrability, and drainage overshadow these desirable chemical characteristics.

Silty clay is a little more friable owing to the higher content of silt.

LIGHT-TEXTURED SOILS	Rating, in per cent
Very fine sand	80
Fine sand	65
Sand	60
Wind-blown sands	20–70

The sands listed above differ in the relative size of the sand particles making up the soil. All have less than 20 per cent total silt and clay particles. The large proportion of sand particles renders these soils open and friable. Water percolation through the soil mass is fairly rapid and is liable to be excessive in the coarser sands. Air moves rapidly through sandy soils and they warm up more quickly in the spring than do heavier-textured soils. This factor renders them desirable for certain specialized truck crops.

The wide range in the rating of wind-blown sands—20 to 70—is due to the great variation in the surface configuration of this type of material. Soils of the Rositas, Coachella, and Oakley series are typical examples

of wind-blown material. The shifting of sand by wind action causes serious difficulties in certain instances. The cost of leveling this type of material for irrigation is relatively high.

The available plant nutrients of sands are low. Large applications of organic material in the form of manures or covercrops are necessary to maintain yields on them, and frequent application of fertilizers is necessary in order to maintain their value for intensive cropping. Moisture must be available at regular intervals during the growing season. This interval and application is necessarily relatively short since the moisture-holding capacity of the sands is small compared with that of the medium-textured soils. The normal moisture capacity will vary from 2–3 per cent in the coarse sand up to 7–10 per cent for the very fine sand. Thus it can readily be seen that the value decreases with the coarseness of the soil.

Sands occurring where there is a high rainfall are leached of their plant nutrients and are usually of very low productive value. Fortunately, the area of such soils in California is limited largely to the northern coast line. Some of the southern coastal plain sands have been moderately leached, but the arid and semiarid sands are fairly good producers when moisture and sufficient organic material are present.

GRAVELLY OR COBBLY SOILS	Rating, in per cent
Gravelly fine sandy loam	70
Gravelly loam	70
Gravelly silt loam	70
Gravelly sandy loam	65
Gravelly clay loam	55
Gravelly clay	35
Gravelly sand	20–30

The presence of gravel in a soil interferes with tillage operations, and, especially in the case of the lighter-textured soils, materially lowers their water-holding power. Suggested ratings are given above. These may have to be lowered or raised according to the amount of gravel present in the soil mass.

STONY SOILS	Rating, in per cent
Stony fine sandy loam	70
Stony loam	70
Stony silt loam	70
Stony sandy loam	65
Stony clay loam	60
Stony clay	35
Stony sand	10–40

Stone in a soil interferes with tillage and all farm operations, and lowers the water-holding capacity and the volume of actual soil from which plants can secure food. The rating of soils containing enough

stone to interfere with farm operations should be lowered. Suggested ratings are given above where the soils have been mapped under such type names in the soil surveys.

FACTOR C: SOIL-MODIFYING CONDITIONS

As mentioned previously, a number of other conditions may exist that modify the value of the soil. These are generally determined by field observations or by a few simple field tests. They are listed with suggested ratings under the following headings and in table 4 (page 38).

DRAINAGE

Soils having a high water table or a fluctuating ground-water level are obviously of lower value than those which are well drained. The past drainage history and the prospects of the soil's becoming water-logged under future utilization should have careful consideration in any system of soil evaluation. Many of the dark-colored alluvial soils are poorly drained, especially those at the lower ends of the alluvial fans where water has accumulated by seepage from the higher lands. Drainage conditions are divided into four classes, each given a rating.

1. Well Drained . . . . 100 per cent.—Soils are considered well drained where the water level is deep and there is no probability of the soil's becoming water-logged.

2. Fair Drainage . . . . 80–90 per cent.—Drainage is considered fair where the water table is sufficiently below the surface so that little crop injury is experienced, and where any excessive water can be taken care of through artificial drains at a low or moderate cost. Areas where there may be some shallow flooding for brief periods are also placed in this class.

3. Moderately Water-logged . . . . 40–60 per cent.—Soils are considered moderately water-logged where the permanent water table is sufficiently close to the surface so that only the shallow-rooted crops can be grown.

4. Badly Water-logged . . . . 10–40 per cent.—Land is considered badly water-logged where the ground water is permanently close to the surface, so that agriculture is limited to very poor wild grasses.

ALKALI

Alkali is often the limiting factor governing the value of desert soils. It consists of an excess of soluble salts that have accumulated in the soil because of poor drainage and excessive surface evaporation (fig. 11).

Chemically, they may be sodium chloride, sodium sulfate, sodium carbonate, etc. Alkali is not normal to humid soils of the eastern part of the United States since it cannot accumulate where there is a high rainfall and the soils are leached.

Recognizing the importance of alkali, careful studies are made of this problem in the soil surveys of desert areas. The harmfulness of alkali is dependent not only on the amount present in the soil, but on its position in the profile, its chemical composition, the texture of the soil, and the



Fig. 11.—White alkali crust, with a native cover of greasewood. This soil is of no value for agriculture because of the high alkali content. (Photograph by W. W. Weir.)

amount of moisture present. Plants do not tolerate a great deal of alkali if it is concentrated as a surface crust, or if it is of the "black" variety (sodium carbonate), or if it is concentrated in a dry soil.

In mapping the alkali of an area such lands have often been classed in four grades[9] with reference to the total content, the kind of alkali, and the visible conditions such as the appearance of the crop or the presence of alkali-tolerant weeds growing on the land (fig. 11).

1. Alkali-free: 100 per cent.—This grade includes areas whose salt content is less than 0.2 per cent and so evenly distributed throughout the soil profile as to be noninjurious to crops.

2. Slightly Affected Areas: 90 per cent.—This grade includes areas whose salt content is usually between 0.2 and 0.6 per cent, but so distributed throughout the soil profile as to have only slight effect on crops.

[9] Strahorn, A. T., *et al.* Soil survey of the El Centro area, California. U. S. Dept. Agr. Bur. Soils, pp. 641–716. 1918.

3. Moderately Affected Areas: 60 per cent.—This grade includes land with a salt content of less than 2 per cent, which is so distributed in the soil profile as to depress the yields of crops, but not prevent their growth. Soils with a much smaller amount of black alkali are rather toxic.

4. Strongly Affected Areas: 5–25 per cent.—Crops are limited and to a large degree prohibited by the alkali content in these areas. The total amount of salts may vary from 1 to 2 per cent or more, as an average throughout the profile, but is usually high in the surface foot—often over 3 per cent. Some of these areas have practically no value for agriculture. Soils with much smaller amount of black alkali (sodium carbonate) may be rather toxic and should be placed in this grade.

ACIDITY

A number of soils exist in California which are acid in reaction (table 1, page 7). The rating of acid soils is reduced according to the degree of acidity, for most crops are injured by excessive acidity of the soil. Suggested ratings vary between 60 and 95 per cent. The hydrogen-ion concentration (usually expressed as pH) of soils is a measure of the intensity of acidity. Soils with a pH of about 7.0 are said to be neutral in reaction; those with a pH of 6.0–6.5, slightly acid; those with a pH of 4.5–6.0, moderately acid; and those with a pH below 4.5, very acid. Alkaline soils have a pH of over 7.0. Soil acidity can be quickly and easily determined by simple tests. A number of field testing kits, satisfactory for approximate determinations of soil reaction, are available.

INFERTILITY

Information can usually be secured about the general fertility of a soil by studying the past cropping history. Where a soil is of lowered fertility, its rating can be lowered by applying a factor here to take care of this. In most cases this will be between 80 and 95 per cent, although in some extreme cases a lower number should be given.

A routine chemical analysis does not give very much information regarding the adaptability of soils to crops, or methods of fertilization,[10] so that field observations on the cropping history and the native vegetation growing on the soil must be used to supplement other information regarding the availability of plant nutrients. Often valuable information can be secured by studying the distribution of crops on each soil series or soil type. Where agriculture has been long established in a re-

[10] Hoagland, D. R. Fertilizer problems and analysis of soils in California. California Agr. Exp. Sta. Cir. 317:1–16. 1930.

gion this information is of great value in rating the productive capacity of the respective soils. "Worn out" or infertile soils can be determined by such a study.

STRATIFIED SUBSOILS (GRAVELLY LAYERS OR STRATIFIED CLAY LAYERS)

Where moisture is a limiting factor in crop growth, the presence of gravelly layers in the alluvial soils is a distinct handicap, since such subsoils are of leachy character with little power of holding moisture for crop use. These gravelly pockets, or subsoil layers, are most common in soils of the Tujunga, Hanford, Yolo, and Elder series, which are of fairly recent deposition. Such pockets are a result of the deposition of gravelly material by fast-moving water, and later deposition of finer and better surface soil over it. These "pockets" are not obvious from surface soil examination, except that crops may appear wilted where there is a deficiency of moisture. The rating given soils having such conditions will naturally vary, although a rating of 80–95 per cent will take care of most cases.

Certain alluvial soils having heavy-textured layers in the subsoils should be discounted in value to some extent. Fairly large areas of soils having such conditions exist in the Imperial Valley. A rating of 80–95 per cent is suggested to cover such conditions.

SHALLOW PHASES OF ALLUVIAL SOILS

In certain extreme cases alluvial soils may be only 2 or 3 feet deep over a flat substratum or bedrock. A rating of 50–60 per cent might be given for a 2-foot depth of soil, and a rating of approximately 70 per cent for alluvial soils about 3 feet in depth.

ERODED SOILS

All soils located on slopes erode or wash to some extent. Under certain conditions of rainfall and removal of the vegetative cover by cultivation, overgrazing, lumbering, and fire, this is hastened, and the soils erode to such an extent that their value is materially lowered[11] (fig. 12). Soils eroded to a moderate extent might be given a rating of 80–95 per cent, while the badly eroded soils, such as those mapped as eroded phases, should be given a much lower figure.

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[11] Weir, Walter W. Soil erosion in California: its prevention and control. California Agr. Exp. Sta. Bul. 538:45. 1932.

STEEP PHASES

Soils occurring on steep slopes are difficult to till, and should be lowered in their rating. Rough mountainous slopes are of still less value. A range in the rating may be 60–80 per cent for soils occurring on slopes that are fairly difficult to till, and 20–30 per cent for soils on steep mountainous slopes.



Fig. 12.—Recent erosion cuts 2 to 3 feet in depth have materially lowered the value of this field. Note deposition of eroded soil material on the flat. (From Bul. 538.)

NONAGRICULTURAL MATERIALS

In most of the soil surveys there is a miscellaneous class of materials that is not classed with the soil series or soil types, but classed under a miscellaneous group. This has little value from an agricultural standpoint. For purposes of rating them, these are given an *index,* although they really belong in a system of land classification rather than in a soil category.

Nonagricultural materials which are mapped under miscellaneous group in soil surveys are as follows:

1. Rough Mountainous Land: 5–10 per cent.—This class of land usually occurs on rougher mountainous topography; it is often good grazing land (fig. 13).

2. Scabland: 5 per cent.—Scabland consists of fairly recent lava flows; contains small patches of soil (fig. 14); it is of very little agricultural value even for grazing.

Rough Broken Land: 5 per cent.—Rough broken land consists of steep slopes, eroded slopes, gullies, and canyon walls, and contains very small areas of arable land.

3. Riverwash: 1–5 per cent.—Riverwash consists of sandy, gravelly, cobbly, or stony deposits of stream channels; subject to erosion and overflow; of no agricultural value.



Fig. 13.—Rough mountainous and rough stony land. Note small cleared area of primary soil (group VI soils). (From Bul. 552.)



Fig. 14.—Scabland: a very thin layer of soil weathered from fairly recent lava flow. It is of very low value. (Photograph from C. F. Shaw.)

Placer Diggings and Tailings: 1–5 per cent.—Areas where placer-mining operations have left the surface covered with stone and gravel are placed in this class.

Tidal Marsh: 1–5 per cent.—Tidal marsh lands are lands subject to inundation by tidal action; they are low, flat, and highly saline.

Coastal Beach: 1–5 per cent.—This class applies to sloping beaches of sand, gravel, or stone.

Dunesand: 1–5 per cent.—Dunesand consists of areas of sand on dunes or ridges; in more or less constant movement with wind.

Rough Stony Land: 1–5 per cent.—This class includes rough, stony slopes (fig. 15). The presence of excessive amounts of stone and large rocks or boulders is the dominant factor.

CALCULATION OF THE INDEX

To use this index method for rating soils it is obviously necessary to know the characteristics of the soils to be rated. This information may be obtained directly by adequately exploring the soil and subsoil to a depth of 6 or more feet throughout the whole area to be rated, supplementing this exploration by field and laboratory studies to determine the less obvious characteristics of the soil. This would require much time and patient investigation, as well as a considerable degree of training in soil studies. Most of the needed information can be obtained from the soil maps and reports if the area to be rated has been covered by the soil survey. The information available in these surveys has already been discussed to some extent, and the Appendix gives further information and lists the areas on which surveys have been completed and are available.

As the soil maps are usually published on the scale of 1 inch to the mile, it is difficult to show on the maps soil bodies that are less than 5 acres in area. Hence in rating any area it is essential that the information supplied by the soil surveys be supplemented by direct field examination to ascertain the less extensive and more intimate characteristics of the soils, and particularly the conditions included in factor C.

From experience in the use of the index it is suggested that the sequence given herewith be followed.

1. Ascertain the characteristics of the soil profile and especially those of the subsoil and substratum, from soil-survey data and field studies. Determine the group in which the soil belongs and develop the rating for factor A.

2. Ascertain the textural characteristics of the surface soils, checking by careful field observations to determine the direction of any local variation from the typical texture. From these studies develop the rating for factor B.

3. Ascertain the presence or absence of alkali, poor drainage, or other soil-modifying conditions. These are more variable in occurrence and extent than the characteristics that determine factors A and B, and re-

quire much more field investigation to determine the intensity of local conditions. From the results of this study, develop the rating for factor C. Unless some specific unfavorable factor is present, the rating for factor C should be 100 per cent.

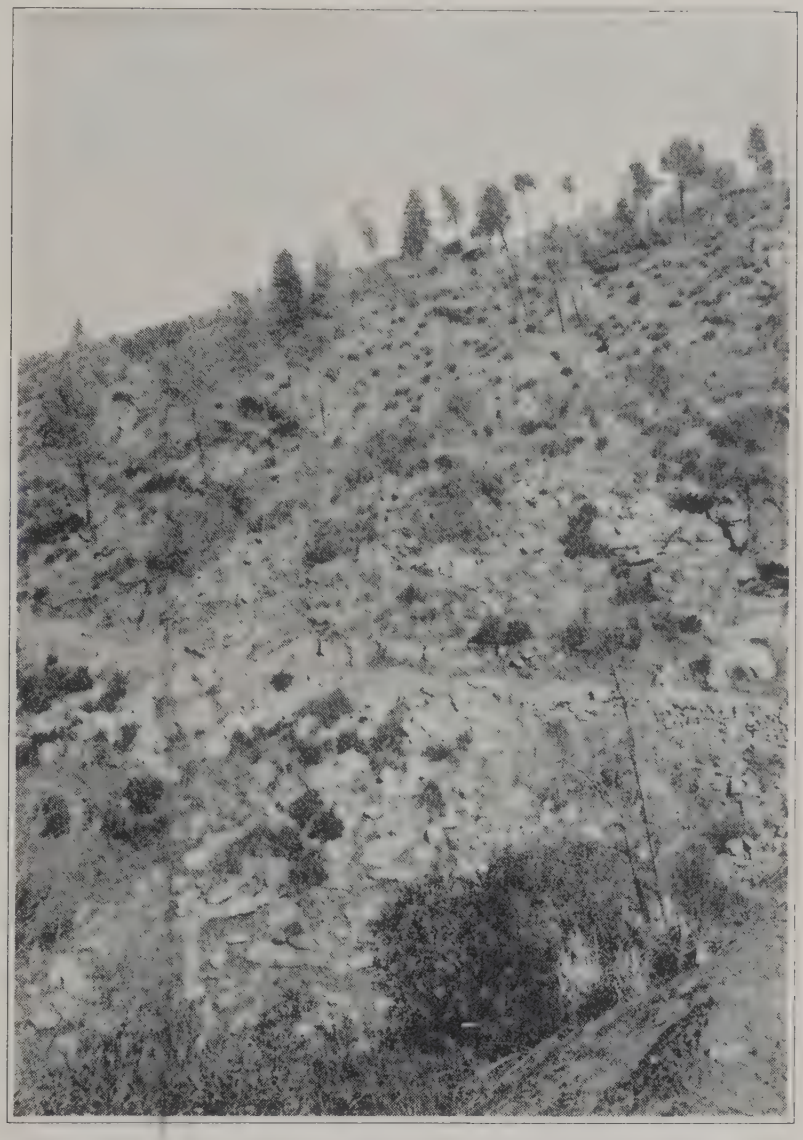


Fig. 15.—Rough stony land, nonagricultural class. It supports growth of brush and a few trees. (Photograph by C. F. Shaw.)

The final soil index is then obtained by multiplying A times B times C. The values and limits assigned to the several divisions of each of the three factors are summarized in table 4 (page 38).

SOIL RATING FOR A TRACT OF LAND

When a tract of land is to be rated, the soil survey, if available, is consulted, and a field examination is made. On the basis of these, a soil map such as that shown in figure 16 is prepared. The index for each soil type in the tract is calculated separately, and then a rating for the entire

tract is calculated by weighting each soil index according to the proportion of the acreage of that soil in the tract. Various tracts of land can be compared by the use of these figures.

For the tract shown in figure 16, the steps in calculation would be as follows:

1. Index for Hfsl, Hanford fine sandy loam: This soil is granitic fine sandy loam of alluvial origin with no compaction or clay accumulation in the subsoil, more than 6 feet in depth, well drained, and has no alkali. It is of high productive value.

	Rating, in per cent
Factor A: Hanford Series, group I	100
Factor B: fine sandy loam (medium-textured soil)	100
Factor C: has no other modifying soil factors	100

$$\textit{Index rating} = \underset{A}{100\%} \times \underset{B}{100\%} \times \underset{C}{100\%} = 100\%$$

2. Index for CSiCl, Chino silty clay loam: This is dark gray alluvial soil of granitic origin, with gray to dark gray subsoils which are calcareous. The soil is more than 6 feet in depth, but has a water table at a depth of 3 feet from the surface.

	Rating, in per cent
Factor A: Chino Series, group I	100
Factor B: silty clay loam (medium heavy)	90
Factor C: moderately water-logged	60

$$\textit{Index rating} = \underset{A}{100\%} \times \underset{B}{90\%} \times \underset{C}{60\%} = 54\%$$

3. Index for Hstl, Holland stony loam: This is brown primary soil from granitic parent material. Bedrock is at an average depth of 3 feet. A considerable number of stones occur throughout soil mass. The surface is gullied to some extent.

	Rating, in per cent
Factor A: Holland Series, group VI (depth 3 feet)	60
Factor B: stony loam (stony)	70
Factor C: eroded surface	80

$$\textit{Index rating} = \underset{A}{60\%} \times \underset{B}{70\%} \times \underset{C}{80\%} = 33\%$$

4. Index for R, rough stony land: The area consists of extremely stony slopes, and is of little value.

$$\textit{Index rating} = 2\%$$

5. The index for the entire tract shown in figure 16 may then be calculated according to the acreage of each soil, as follows:

Soil	Index	Acreage	
Hanford fine sandy loam	100	× 95	= 9,500
Chino silty clay loam	54	× 10	= 540
Holland stony loam	33	× 65	= 2,145
Rough stony land	2	× 30	= 60
Total	200		12,245

$$\text{Tract rating} = \frac{12{,}245}{200} = 61.$$

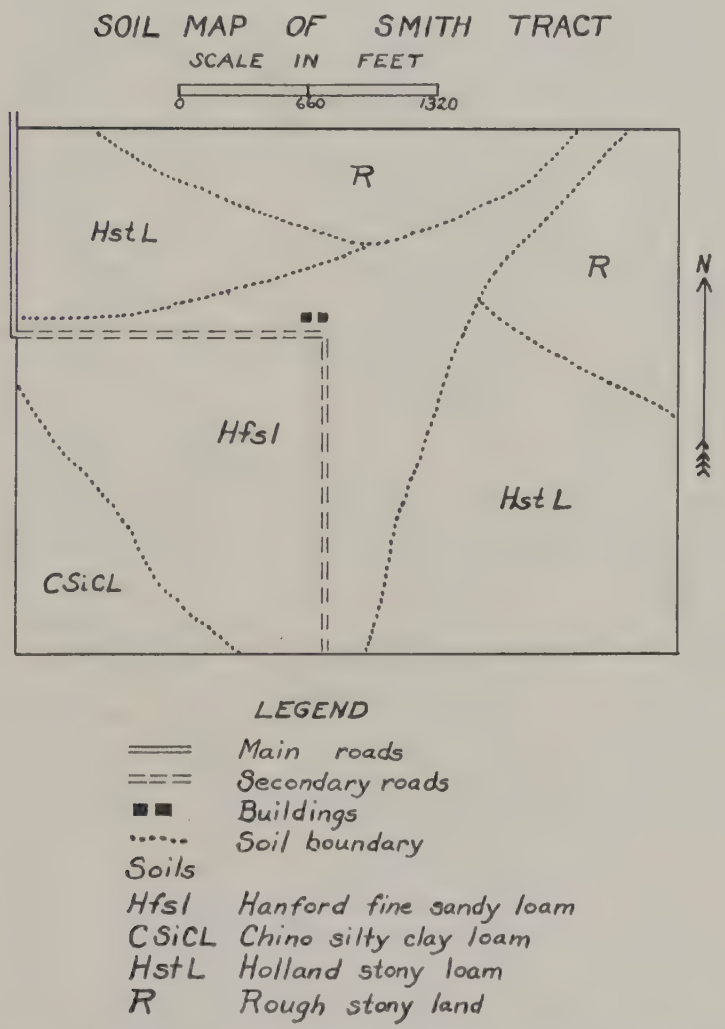


Fig. 16.—Soil map of a tract of land, which is made by field examination. The figures listed below give the types, their acreage, index, and grading.

Types	Acreage	Index	Grade
Hanford fine sandy loam	95	100	1—Excellent
Chino silty clay loam	10	54	3—Fair
Holland stony loam	65	33	4—Poor
Rough stony land	30	2	5—Very poor, non-agricultural

TABLE 4

SOIL RATING CHART—FOR RATING OR JUDGING THE AGRICULTURAL VALUE OF SOILS

(Soil Index Rating = Factor A × Factor B × Factor C)

Factor A, Rating of soils on basis of character of profile		Factor B, Rating of soils on basis of surface texture		Factor C, Rating of conditions and characteristics of the soil which modify its suitability for utilization in plant production	
Soil group	Rating, in per cent	Texture	Rating, in per cent	Condition	Rating, in per cent
I. Unweathered or slightly weathered secondary soils	95–100	Medium-textured:		Drainage:	
		fine sandy loam	100	well drained	100
		loam	100	fair drainage	80–90
II. Moderately weathered secondary soils	80–95	silt loam	100	moderately water-logged	40–60
		sandy loam	95	badly water-logged	10–40
III. Strongly weathered secondary soils with dense clay subsoils, developed on unconsolidated parent material	40–80	coarse sandy loam	90	Alkali:	
		loamy sand	80	alkali free	100
		Medium-heavy textured:		slightly affected	90
		silty clay loam	90	moderately affected	60
		clay loam	85	strongly affected	5–25
IV. Maturely weathered secondary soils with hardpan:		Heavy-textured:		Acidity:	
		silty clay	65	according to degree	60–95
		clay and adobe clay	50–70	Infertility:	
Hardpan less than 1 foot	5–10	Light-textured:		according to degree	60–95
1–2 feet	10–20	very fine sand	80	Stratified subsoils	60–95
2–3 feet	20–30	fine sand	65	Shallow phases of alluvial soils:	
3–4 feet	30–40	sand	60	2 feet deep	50–60
4–6 feet	40–60	wind-blown sand	20–70	3 feet deep	70
V. Strongly weathered soils having dense clay subsoils resting on consolidated material	20–40	Gravelly or cobbly:		Eroded soils:	
		gravelly fine sandy loam	70	moderate	80–95
		gravelly loam	70	badly	30–80
		gravelly silt loam	70	Steep phases:	
		gravelly sandy loam	65	fairly steep	60–80
VI. Primary soils underlaid by bedrock:		gravelly clay loam	55	steep	20–30
Depth less than 1 foot	20–25	gravelly clay	35		
1–2 feet	25–40	gravelly sand	20–30		
2–3 feet	40–60	Stony:			
Over 3 feet	60–70	stony fine sandy loam	70		
		stony loam	70		
		stony silt loam	70		
		stony sandy loam	65		
		stony clay loam	60		
		stony clay	35		
		stony sand	10–40		

Miscellaneous nonagricultural material

Type	Description	Rating in per cent
Rough mountainous land	Rough mountainous topography	5–10
Scabland	Recent lava flows	5–10
Rough broken land	Steep slopes, eroded slopes, gullies, and canyon walls	5–10
Riverwash	Deposits of stream channels	1– 5
Placer diggings and tailings	Piles of stone and gravel	1– 5
Tidal marsh	Tidal lands	1– 5
Coastal beach and dunesand	Sloping beaches of sand, gravel	1– 5
Rough stony land	Rough stony slopes	1– 5

SUMMARY

Soils vary in their productive capacity.

There is need for some method of comparing the relative productive capacity of different soils, especially in California where such a large number of widely divergent soil conditions exist. Such a soil rating or index would be useful in land classification and land evaluation.

In this paper the term "index for rating soils" is used to express this relative rating. Soils having the highest productive capacity (from a study of the soil under field conditions) are rated at 100 per cent.

The rating is based on the study of three general factors: A, character of the soil profile; B, texture; and C, modifying conditions.

Index numbers are used for each group of factors based on 100 per cent expressing ideal conditions.

The characteristics listed under factor A, character of the soil profile, are essentially those that determine the soil series. A grouping of the soil series of California is given according to their position in the six groups on the basis of factor A. Factors A and B together make up the soil type.

Characteristics listed under factor C, modifying conditions, consist of drainage conditions, alkali, etc.

The index is the product of the ratings given each of these three factors, $A \times B \times C$, the ratings and the final index being expressed in percentages.

By the use of this method of rating soils, a large number of divergent types can be compared, or various tracts of land can be compared from the soil standpoint.

The index for rating the agricultural value of soils presented in this bulletin can be used as a basis for judging soils.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance and advice of Professor C. F. Shaw and Professor W. W. Weir in the preparation of this paper. Helpful suggestions were also made by Mr. J. H. Keith, County Assessor of Riverside County.

LIST OF SELECTED REFERENCES

For the information of those who wish to secure more specific soil data, the following short list of books, bulletins, and circulars will be found to contain valuable information. In addition to those listed below, many other good books and publications are available, but the publications listed below will be found of particular use to those who do not find time for extended reading on this subject. Practical information on California soils can also be secured by consulting papers published in the American Journal of Agronomy, Proceedings of the American Soil Survey Association, Soil Science, and other similar publications.

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1927. The basis of classification and key to the soils of California. Proc. 1st Intntl. Congr. Soil Sci. 4:65–104.
1927. Profile development and the relationship of soils of California. Proc. 1st Intntl. Congr. Soil Sci. 4:291–318.

UNITED STATES DEPARTMENT OF AGRICULTURE.
Soil survey reports and maps (for the area in which the reader is interested.)[12]

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1932. Soil erosion in California: its prevention and control. California Agr. Exp. Sta. Bul. 538:1–45.

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12 See Appendix for soil surveys completed in California.

APPENDIX: SOIL SURVEY DATA IN CALIFORNIA

There are two general types of soil surveys, the reconnoissance and the detailed, that cover portions of California. The extent of these surveys is shown on the map in figure 17. Reconnoissance surveys (shown on the insert in fig. 17) are generalized soil surveys with maps made on the scale of 1 inch to 2 miles or 1 inch to 4 miles. Seven such surveys were made during the period between 1913 and 1917, covering the major portion of southern California, the Sacramento and San Joaquin valleys, and the San Francisco Bay region. These show the soils in rather inclusive groupings and rarely show bodies of soil less than 160 acres.

They are being supplanted as rapidly as facilities permit by detailed soil surveys with maps made on the scale of 1 inch to 1 mile. On these maps the bodies of soils as small as 5 or 10 acres in extent are shown. All the soil maps are accompanied by reports giving a full description of the soil types shown with a discussion of their geographical distribution, relationship, and general utilization in that particular area. Where alkali is present to any extent a separate alkali map is published. In addition to the soil discussion, separate chapters are written covering the general description of the area, the climate, the agriculture, and often separate chapters on irrigation, drainage, and alkali conditions are included. In recent publications, there is also a technical discussion of the soils.

These soil surveys serve as an inventory of the soil resources of the state and as a background for soil classification, soil evaluation, and other studies. Before extensive studies can be made on individual soil series or soil types, it is necessary to know in detail the characteristics of these soils, and also the location, the general environment, and the extent of their occurrence. Basic studies on individual soil series or on groups of soil series are now in progress and in due time this soil information will become available in printed form.

Completed soil surveys available in printed form are listed in table 5, those out of print in table 6, and those completed but not yet published in table 7.

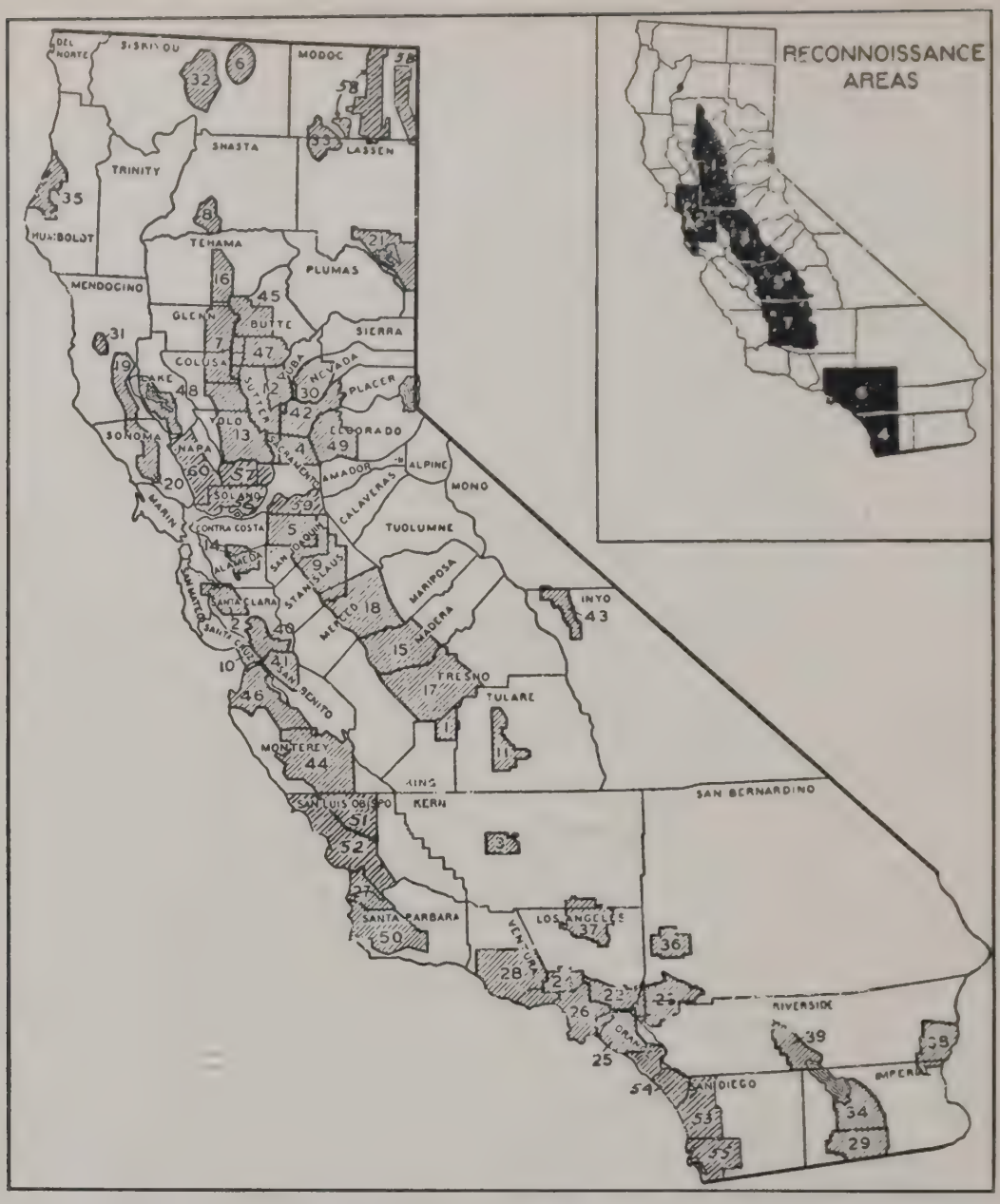


Fig. 17.—Soil-survey areas in California shown by shading:

1. Hanford
2. San Jose
3. Bakersfield
4. Sacramento
5. Stockton
6. Butte Valley
7. Colusa
8. Redding
9. Modesto-Turlock
10. Pajaro Valley
11. Porterville
12. Marysville
13. Woodland
14. Livermore
15. Madera
16. Red Bluff
17. Fresno
18. Merced
19. Ukiah
20. Healdsburg
21. Honey Lake
22. Pasadena
23. Riverside
24. San Fernando
25. Anaheim
26. Los Angeles
27. Santa Maria
28. Ventura
29. El Centro
30. Grass Valley
31. Willits
32. Shasta Valley
33. Big Valley
34. Brawley
35. Eureka
36. Victorville
37. Lancaster
38. Palo Verde
39. Coachella Valley
40. Gilroy
41. Hollister
42. Auburn
43. Bishop
44. King City
45. Chico
46. Salinas
47. Oroville
48. Clear Lake
49. Placerville
50. Santa Ynez
51. Paso Robles
52. San Luis Obispo
53. Oceanside
54. Capistrano
55. El Cajon
56. Suisun
57. Dixon
58. Alturas
59. Lodi
60. Napa

TABLE 5

SOIL SURVEYS AVAILABLE IN PAMPHLET FORM, 1932*

Number as shown on map (fig. 17)	Area	Date of survey	Number as shown on map (fig. 17)	Area	Date of survey
25	Anaheim	1916	47	Oroville	1926
42	Auburn	1923	38	Palo Verde Valley	1922
33	Big Valley	1920	22	Pasadena	1915
43	Bishop	1924	49	Placerville	1926
34	Brawley	1920	23	Riverside	1915
45	Chico	1925	46	Salinas	1925
48	Clear Lake	1927		San Diego Reconnoissance	1915
39	Coachella Valley	1923	24	San Fernando	1915
29	El Centro	1918		San Francisco Bay Reconnoissance	1914
35	Eureka	1921			
40	Gilroy	1923	50	Santa Ynez	1927
30	Grass Valley	1918	27	Santa Maria	1916
41	Hollister	1923	32	Shasta Valley	1919
21	Honey Lake	1915		Central-Southern California Reconnoissance	1917
44	King City	1924			
37	Lancaster	1922		Upper San Joaquin Reconnoissance	1917
26	Los Angeles	1916			
	Lower San Joaquin Reconnoissance	1915	28	Ventura	1917
			36	Victorville	1921
	Middle San Joaquin Reconnoissance	1916	31	Willits	1918
			13	Woodland	1909

* Can be secured from the Division of Soil Technology, University of California, Berkeley, California.

TABLE 6

SOIL SURVEYS NO LONGER AVAILABLE FOR FREE DISTRIBUTION, 1932*

Number as shown on map (fig. 17)	Area	Date of survey	Number as shown on map (fig. 17)	Area	Date of survey
3	Bakersfield†	1904	9	Modesto-Turlock†	1908
6	Butte Valley	1907	10	Pajaro Valley	1908
7	Colusa	1907	11	Porterville†	1908
	Fresno†	1900	8	Redding	1907
17	Fresno†	1912	16	Red Bluff	1910
1	Hanford†	1901	4	Sacramento	1904
20	Healdsburg	1915		Sacramento Valley Reconnoissance	1913
	Imperial†	1901			
	Imperial†	1903		San Bernardino†	1904
	Indio†	1903		San Gabriel†	1901
	Klamath Reclamation	1908	2	San Jose†	1903
14	Livermore Valley†	1910		Santa Ana†	1900
	Los Angeles†	1903	5	Stockton†	1905
	Lower Salinas Valley	1901	19	Ukiah	1914
15	Madera†	1910		Ventura†	1901
12	Marysville	1909		Yuma	1904
18	Merced†	1914			

* May be consulted at the principal public libraries in bound volumes of the Annual *Field Operations of the Bureau of Soils.*

† Covered by more recent surveys.

TABLE 7

SOIL SURVEYS COMPLETED BUT NOT YET PUBLISHED, 1932

Number as shown on map (fig. 17)	Area	Date of survey	Number as shown on map (fig. 17)	Area	Date of survey
51	Paso Robles	1928	56	Suisun	1930
52	San Luis Obispo	1928	57	Dixon	1931
53	Oceanside	1929	58	Alturas	1931
54	Capistrano	1929	59	Lodi	1932
55	El Cajon	1929	60	Napa	1932

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UNIVERSITY OF CALIFORNIA
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BERKELEY, CALIFORNIA

AN ANALYSIS OF THE FRESNO MILK MARKET

J. M. TINLEY

BULLETIN 559
OCTOBER, 1933

CONTRIBUTION FROM THE
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

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FOREWORD

This bulletin represents the third of a series of studies on milk-marketing in California made by the Giannini Foundation of Agricultural Economics, College of Agriculture, University of California, during the years 1930, 1931, and 1932. The results of the first study dealing with the Los Angeles milk market were presented in California Agricultural Experiment Station Bulletin 513. The second study, appearing in Bulletin 534, dealt with the East Bay milk market.

The three studies cover problems common to all milk markets in the state as well as problems peculiar to each separate market. The fact that only four distributors operated in Fresno at the time this study was conducted made it possible to make a more detailed analysis of the system of distribution than was possible in the two earlier studies. Special stress was placed on the system of distribution in Fresno, moreover, because the inefficiency of the system in that city appeared to be one of the prime factors responsible for the troubles of the market-milk industry of that area.

These studies have, of course, emphasized problems that are pressing during periods of declining demand and falling prices. Conditions in many milk markets have, however, been aggravated by factors which had their origin during the so-called period of prosperity and stable price levels prior to 1929. All the studies have attempted to show that the best interests of both producers and distributors are concerned with the maintenance of a high level of per-capita consumption of market milk. This can be done only if prices paid by consumers for market milk are kept at all times at the lowest possible level consistent with good quality and the adequate protection of the health of consumers. If this objective is to be attained, it is necessary that every effort be made to increase the efficiency of production and distribution of market milk. This problem warrants the cooperation of all groups interested in the market-milk industry of California.

It is hoped that the three bulletins will be useful to all in the state who are directly or indirectly interested in the economic problems of market-milk production and distribution. These bulletins have emphasized especially the economic factors which have a bearing on the long-time stability of the market-milk industry in the different parts of the state.

It is suggested that this bulletin be read in conjunction with bulletins 513 and 534. Much of the analysis developed in those bulletins relative to the economic interrelations between production, consumption, and distribution have not been repeated in the present bulletin.

AN ANALYSIS OF THE FRESNO MILK MARKET[1,2]

J. M. TINLEY[3]

INTRODUCTION

During the past two years different groups have voiced complaints from time to time about the prices paid by consumers for market milk in Fresno and about the prices received by dairymen. At the same time very few persons seemed to have had any very definite ideas as to the factors responsible for the alleged unsatisfactory state of affairs. Several groups representative of different interests in the Fresno milk market requested the Giannini Foundation of Agricultural Economics, College of Agriculture, University of California, to make an economic analysis of the Fresno milk market. In response to this request, a study was commenced early in December, 1932. This report represents the information collected during the course of the study, the conclusions reached, and the recommendations made.

The purposes of the study were (1) to analyze the economic factors affecting the long-time stability of the Fresno milk market, and (2) to ascertain whether it would be possible to effect any economies in or reorganization of the present methods of handling milk which would lead to an immediate and lasting improvement of milk-marketing conditions in Fresno.

The information on which this study is based was obtained from the records of the four milk distributors in Fresno, from the records of the Bureau of Dairy Control, California Department of Agriculture, Sacramento, and from the records of the Health Department of the city of Fresno.[4] Personal interviews were held with numerous producers, sev-

[1] Received for publication May 1, 1933.

[2] Paper No. 43, the Giannini Foundation of Agricultural Economics.

[3] Associate Agricultural Economist in the Experiment Station and Associate Agricultural Economist on the Giannini Foundation.

[4] The firm of Burdick and Freeland, accountants and auditors of Fresno, assisted the author in securing information from the records of the four distributors in Fresno, and from the records of the Health Department of the city of Fresno. The services of this firm were paid for out of a contribution of $400 subscribed equally by producers and distributors in Fresno.

eral retail-grocery merchants, city officials, and officers connected with the various distributing plants. No attempt was made to analyze in detail costs of producing and distributing market milk because it was considered that such data as could be obtained on costs would be of little assistance in determining "fair" margins for distributors and "fair" prices for dairymen. Moreover, the collection of such data was likely to be a long and costly undertaking. Information was obtained from the distributors, however, concerning the importance of some of the chief cost factors entering into the production of market milk. In addition, each of the distributors made available copies of their profit and loss statements for 1930, 1931, and 1932.

GENERAL BUSINESS CONDITIONS AND THE MARKET-MILK INDUSTRY

The economic life of all commercial countries seems to be characterized by periodical advances and declines in business conditions. Many of these advances and declines, known as secular movements, cover long periods of time and are said to result from long-time changes in the relation between the volume of money and the volume of trade. In addition, there are shorter and somewhat more regular cyclical movements of business conditions known as business cycles. In both these types of movements the upswings of business conditions are characterized by increases in prices generally, rising business profits, expansion of industry and volume of trade, a high level of employment, and higher wage scales. The reverse is true in the case of business recessions.

The years 1921–1929 marked a period of comparative business prosperity, although some industries, especially some branches of agriculture, did not share in the generally prosperous conditions. One of the most severe business depressions this country has ever experienced began toward the end of 1929. Prices of nearly all commodities fell rapidly and unemployment increased. Even those who were employed had their earnings greatly curtailed. The effects of the business recession were felt most severely in those industries in which productive capacity had been expanded greatly in excess of consumption requirements and in those industries which produced luxury or convenience goods.

The prosperity of the dairy industry is closely related to general business conditions. A large part of the annual milk-fat production in the United States is converted into butter, the demand for which increases when business conditions are good and there is a high level of employment and declines when business conditions are adverse and there

is much unemployment. Figure 1 shows clearly the close relation between butter prices and the index of employment.

The wholesale and retail prices of other dairy products in turn bear some relation to the prices of butter, although the prices of some of them, and especially those of market milk, do not react as rapidly to changed business conditions as do butter prices. This is illustrated by the relation between wholesale butter prices in San Francisco[5] and the

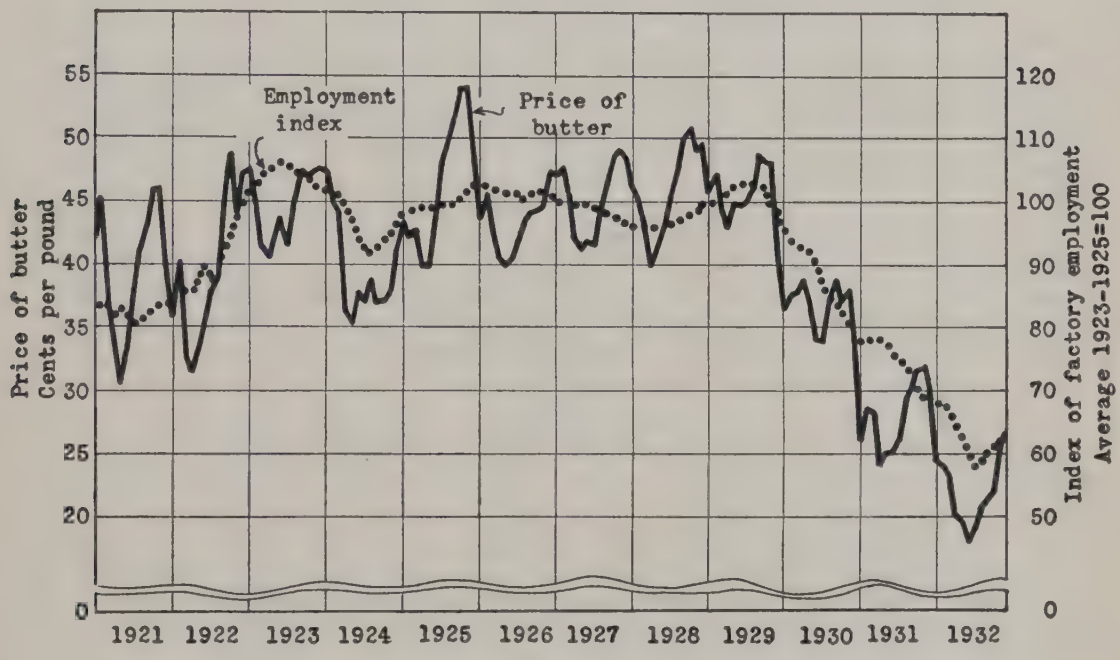


Fig. 1.—Butter prices rise and fall with increases or decreases in employment. (From Agr. Ext. Cir. 71.)

retail prices of market milk in the East Bay cities (table 1). Similar conditions hold for other milk markets. The tardiness of retail prices of market milk in changing with business conditions and with the prices of butter were to a large extent responsible for the numerous milk wars and unsettled milk-marketing conditions in many cities of California and other parts of the United States during the years 1930, 1931, and 1932.

While the city of Fresno had not experienced a milk war during these three years, conditions in the market-milk industry in that city were very unsettled at the time this study was undertaken. Producers were complaining that the prices they received were insufficient to enable them to operate without incurring severe losses. Consumption of market milk in the city of Fresno had declined appreciably since 1929.

[5] Butter is usually retailed at a fixed differential over wholesale prices.

TABLE 1

MONTHLY WHOLESALE PRICES OF BUTTER AT SAN FRANCISCO AND RETAIL PRICES OF MARKET MILK IN THE EAST BAY CITIES, 1929–1932

Year and month	Butter		Market milk		Year and month	Butter		Market milk	
	Actual price	Per cent of average 1929	Actual price	Per cent of average 1929		Actual price	Per cent of average 1929	Actual price	Per cent of average 1929
	cents per lb.	*per cent*	*cents per qt.**	*per cent*		*cents per lb.*	*per cent*	*cents per qt.**	*per cent*
1929					1931				
January	45.9	100.4	14.0	100	January	26.2	57.3	11.4	81.4
February	47.5	103.9	14.0	100	February	28.5	62.4	13.0	92.9
March	44.6	97.6	14.0	100	March	28.2	61.7	13.0	92.9
April	43.1	94.3	14.0	100	April	24.3	53.2	13.0	92.9
May	45.0	98.5	14.0	100	May	25.3	55.4	13.0	92.9
June	44.8	98.0	14.0	100	June	25.0	54.7	13.0	92.9
July	45.0	98.5	14.0	100	July	26.2	57.3	13.0	92.9
August	46.1	100.9	14.0	100	August	29.6	64.8	13.0	92.9
September	48.7	106.6	14.0	100	September	30.5	66.7	13.0	92.9
October	48.3	105.7	14.0	100	October	31.9	69.8	13.0	92.9
November	48.0	105.0	14.0	100	November	32.0	70.0	13.0	92.9
December	41.7	91.2	14.0	100	December	29.7	65.0	13.0	92.9
1930					1932				
January	36.5	79.9	14.0	100	January	24.4	53.4	12.5	89.3
February	37.6	82.3	14.0	100	February	24.0	52.5	12.0	85.7
March	37.7	82.5	14.0	100	March	22.9	50.1	12.0	85.7
April	38.8	84.9	14.0	100	April	20.0	43.8	12.0	85.7
May	36.7	80.3	14.0	100	May	19.5	42.7	12.0	85.7
June	34.0	74.4	14.0	100	June	17.9	39.2	12.0	85.7
July	33.9	74.2	14.0	100	July	18.9	41.4	12.0	85.7
August	37.2	81.4	14.0	100	August	20.7	45.3	12.0	85.7
September	39 0	85.3	14.0	100	September	21.0	46.0	12.0	85.7
October	37.1	81.2	12.0	85.7	October	21.9	47.9	12.0	85.7
November	34.1	74.6	11.0	78.6	November	25.7	56.2	12.0	85.7
December	33.1	72.4	10.0	71.4	December	26.9	58.9	12.0	85 7

* Delivered to home of consumers.

Sources of data:

Butter prices: Average of daily prices published by the U. S. Dept. Agr. Market News Service (San Francisco office).

Market-milk prices: Records of distributors in East Bay cities.

CONSUMPTION

Population.—The incorporated city of Fresno is situated in Township 3 in Fresno County. The population of the city of Fresno in 1930 was 52,513, which was 36.4 per cent of the population of the county. The city of Fresno is surrounded by a number of suburbs, nearly all of which are situated in Township 3, the urban population of which was 69,643. It is probable that most of the difference between the urban population of Township 3 and the incorporated city of Fresno was to be accounted for by the population of the suburbs of Fresno. The population of Fresno County increased from 128,779 in 1920 to 144,379 in 1930, a percentage

increase of 12.1. The population of the incorporated city of Fresno increased during the same period from 45,086 to 52,513, an increase of 16.5 per cent.[6] There are no figures available as to the increase in the population of the suburbs of Fresno, but statements made by officials of the city indicate that most of the suburbs have been built up largely since 1920. It is difficult to ascertain with any degree of accuracy what the trend in population of the incorporated city of Fresno has been since 1930. It is probable, however, that the population has shown little increase since 1930 and may even have shown some decline.[7]

Consumption of Market Milk.—The volume of market milk distributed in Fresno County increased more or less steadily from 1926 to 1930 (table 2). In 1931 there was a decrease of over 130,000 gallons.

TABLE 2

Volume of Milk Distributed in Fresno County, Fresno and Suburbs, and Fresno City, 1926–1932
(In gallons)

Year	Fresno County		Fresno and suburbs		City of Fresno (4 plants)	
	Annual	Daily	Annual	Daily	Annual	Daily
1926	2,052,000	5,622	1,757,000	4,814	.....	.....
1927	2,433,000	6,666	1,743,000	4,775	.....	.....
1928	2,426,000	6,628	1,871,000	5,112	.....	.....
1929	2,645,000	7,246	1,813,000	4,967	1,708,000	4,679
1930	2,684,000	7,353	1,803,000	4,940	1,627,000	4,458
1931	2,550,000	6,986	1,852,000	5,074	1,580,000	4,329
1932	2,375,000*	6,507	.....†	.....†	1,455,000	3,986

* Preliminary.

† Figures not available.

Sources of data:
Fresno County: California State Dept. of Agr. Bur. of Dairy Control. Statistical reports of California dairy records. Annual issues, 1926-1931.
Fresno and suburbs: Estimates based on records of California Dept. Agr. Bur. of Dairy Control.
City of Fresno: Data from records of milk distributors in Fresno and records of State Dept. of Agr. Bur. of Dairy Control.

There was a further decrease in volume distributed in 1932. Over 70 per cent of the milk distributed in Fresno County in 1931 was handled by plants situated in Fresno and its suburbs; over 60 per cent of the county total was distributed by plants situated within the Fresno city limits. The volume of milk handled by these plants has declined appreciably since 1929. It is probable that this decline in volume distributed

[6] See: U. S. Dept. Com. Bur. of the Census. Fourteenth and Fifteenth Censuses of the United States. Population.

[7] This conclusion is borne out by statements made by various officials of the city of Fresno and by several business firms.

has been due partly to a decline in per-capita consumption, and partly, as will be shown later, to a loss of trade to distributors in the suburbs of Fresno.

No reliable figures are available relative to the per-capita consumption in either Fresno County, or the city of Fresno. There are large numbers of dairy farmers in Fresno County, most of whom undoubtedly consume milk produced on their own farms, and this milk would not be shown in the totals in table 2. In 1930 several of the plants situated outside the

TABLE 3

TREND IN PRICES OF MOST IMPORTANT AGRICULTURAL PRODUCTS OF FRESNO COUNTY

Product	Price used	Unit	1928	1929	1930	1931	1932	Decline of 1932 from 1928
			dollars	*dollars*	*dollars*	*dollars*	*dollars*	*per cent*
Apricots	Farm price	Ton	50.00	63.00	39.00	29.00	18.00	64.0
Grapes (table)	Farm price	Ton	26.00	35.00	20.00	35.00	16.00	38.5
Grapes (wine)	Farm price	Ton	25.00	35.00	20.00	19.00	12.00	52.0
Raisins	Farm price	Dry ton	40.00	61.00	59.00	60.00	39.00	2.5
Butter, extra	Wholesale price San Francisco	Pound	0.46	0.46	0.36	0.28	0.22	52.3
Cantaloupes	Farm price	Crate	1.07	0.86	0.99	0.87	0.62	42.0
Watermelons	Farm price	1,000 melons	133.00	115.00	88.00	100.00	59.00	55 6
Alfalfa*	Wholesale price San Francisco U.S. No. 1	Ton	19.65	20.80	16.20	14.80	12.25†	37.7

* Crop-year basis.

† Nine months average, April to December.

Sources of data:

Table and wine grapes and raisins: California Crop Reporting Service, Summary of California annual fruit and nut crop, mimeographed reports.

Butter: Monthly reports of U. S. Bur. Labor Statistics. Wholesale prices.

Cantaloupes and watermelons: California Crop Reporting Service. Annual mimeographed summary of the vegetable acreage.

Alfalfa: Braun, E. W. Alfalfa. California Agr. Exp. Sta. Bul. 521: 34, table 15. 1931.

Fresno city limits distributed milk in that city. But although their total volume of production is known, it is not possible to estimate how much of it was distributed within the city limits during that year. While figures on the volume of milk distributed within the Fresno city limits are available for the years 1931 and 1932, there are no reliable estimates relative to the trend in population since 1930.

A large part of the population of Fresno County is engaged in agriculture. The prosperity of the farmers in the country surrounding the city of Fresno is bound to affect the prosperity of the city of Fresno and vice versa. Since 1929 the prices of most agricultural commodities produced in Fresno County have declined appreciably (see table 3). The decrease in purchasing power of the farm population has in turn ad-

versely affected the purchasing power of the population of the city of Fresno. With a decrease in purchasing power, it would be expected that a lower volume of market milk would be sold at the retail prices prevailing in 1929. Or, if the volume sold is to be maintained, prices would have to be reduced appreciably.

A comparison of percentage changes of market milk prices in Fresno and of retail food prices in San Francisco which can be expected to have changed in much the same ratio as those in Fresno, is given in table 4 for the period January, 1929, to December, 1932. As will be shown

TABLE 4

Relative Changes in Retail Prices of Foodstuffs in San Francisco and Prices Paid for Market Milk by Consumers in Fresno, 1929–1932

(Average relatives of prices for 1929 = 100)

Year and month	Retail prices of foodstuffs in San Francisco	Prices paid by consumers for market milk in Fresno	Year and month	Retail prices of foodstuffs in San Francisco	Prices paid by consumers for market milk in Fresno
1929:			1931:		
January	99.3	98.0	January	86.6	78.6
April	97.0	100.0	April	82.5	78.6
July	100.0	100.0	July	78.8	78.6
October	103.7	100.0	October	78.4	78.6
1930:			1932:		
January	100.1	100.0	January	73.1	78.6
April	98.8	100.0	April	71.0	78.6
July	93.6	78.6	July	67.2	71.4
October	94.1	78.6	October	69.2	71.4

Sources of data:
Retail prices of foodstuffs in San Francisco: U. S. Dept. of Labor Bur. Labor Statistics. Monthly bulletin on prices, wholesale and retail and costs of living. Monthly issues.
Market-milk prices: Calculations based on information supplied by distributors in Fresno.

later (page 40), approximately 61 per cent of the market milk sold in Fresno is distributed through retail grocery stores. Because of this, store prices of market milk are used instead of prices on milk delivered to the door of the consumer. It will be seen that prices of market milk declined practically in the same proportion as prices of foodstuffs generally. It is significant that while there has probably been an appreciable decline in consumption of market milk in Fresno since 1929, the decline has not been as marked as in some of the other cities in the United States, where consumption has declined as much as 30–40 per cent.[8]

[8] Bartlett, R. W. Economic problems in the retail distribution of market milk. p. 9. Illinois Agr. Exp. Sta. Mimeographed release. 1932.

Retail prices of market milk (sold through stores and delivered to the door of the consumer) were 12 cents a quart up to February, 1929. In March, 1929, prices were increased to 14 cents, owing to the payment of higher prices to dairymen for milk produced under the more rigid sanitary requirements which came into effect at that date. In May, 1930, delivered prices were reduced to 13 cents a quart and store prices to 11 cents a quart. A further reduction of delivered and store prices to 12 and 10 cents respectively took place in July, 1931. In November, 1931, delivered prices were again reduced to 11 cents, but no change took place in store prices.

Although prices paid by consumers in Fresno for market milk declined about as much as prices of foodstuffs generally during the years 1929 to 1932, it is possible, as will be shown later, that if distributive facilities had been more closely adjusted to consumption requirements and if methods of handling milk had been more economical and efficient, prices paid by consumers could have been reduced still further and more rapidly. If the volume of milk distributed in Fresno is to be increased, or if a further decrease is to be avoided, it is highly desirable that every effort be made to effect a further decrease in the prices paid by consumers.

The price paid by the consumer is made up of the price paid to the producer of milk, charges for hauling from the dairy farms to city plants, and distributors' margins for processing and selling milk. These various prices, charges, and margins will be analyzed with a view to determining whether it would be possible to effect any economies which could be reflected back to the consumer in the form of a lower price.

Seasonal Variation of Consumption.—Consumption is lowest during the month of January and highest during the months September to November (table 5). There does not appear to be much variation in consumption during the months February to August. Ordinarily it would be expected that the volume of milk consumed during the summer months would increase, because of an increase in per-capita consumption. In the case of Fresno, however, large numbers of permanent residents, especially school children, leave for summer resorts. The decline in the number of consumers during the summer months thus tends to offset any increase in per-capita consumption. The appreciable increase in consumption during the months September to November is due largely to the seasonal increase in population occasioned by the influx of large numbers of fruit-pickers and workers in fruit-packing sheds.

TABLE 5

SEASONAL VARIATION OF CONSUMPTION* IN THE CITY OF FRESNO, 1930–1932

Month	1930	1931	1932	Total for 3 years	Indexes of seasonal variation†
	gallons	*gallons*	*gallons*	*gallons*	
January	123,476	130,379	114,319	368,174	91.0
February	127,990	123,322	111,393	362,705	98.7
March	134,036	132,392	123,178	389,606	97.5
April	132,167	131,478	120,166	383,811	99.6
May	141,924	139,097	124,008	405,029	101.9
June	136,785	128,060	118,060	382,905	99.9
July	133,022	135,449	118,239	386,710	98.1
August	129,500	134,058	120,040	383,598	97.7
September	138,221	135,438	125,485	399,144	105.5
October	143,341	137,440	127,181	407,962	104.8
November	143,227	122,400	125,147	390,774	104.1
December	143,685	130,106	117,403	391,194	101.2
Total	1,627,374	1,579,619	1,444,619	4,651,612	100.0

* Figures are for gallons of milk distributed, the volume distributed being regarded as equal to the volume consumed.

† Corrected for trend.

Source of data:

Calculations based upon records of distributors. During 1930 and the first four months of 1931 some milk was distributed in the city by plants situated in the suburbs. The volume of milk distributed by these plants in Fresno was so small that it would probably not modify the above figures greatly.

SANITARY REQUIREMENTS

Prior to March, 1929, the sanitary regulations of the city of Fresno governing the production and distribution of different grades of market milk were substantially the same as those provided for in the Pure Milk Act of the State of California.[9] In March, 1929, however, stricter sanitary regulations regarding market milk were introduced by the Health Department of the city of Fresno.[10] These regulations were still in effect at the time this study was made.

The new regulations prohibit the sale in Fresno of ungraded raw or pasteurized milk. All grade-A milk, whether raw or pasteurized, is required to be produced from healthy, nonreacting tuberculin-tested cows. Cows are inspected at least once each month and are tuberculin-tested at least every six months. All reacting cows have to be removed immediately. Dairies are required to score at least 80 per cent on the dairy-farm score card adopted by the Department of Agriculture, State of California. Milk has to be cooled to 55° Fahrenheit immediately after milking and kept at that temperature until delivered to the consumer.

[9] Approved June 3, 1927. Statutes 1927, p. 1944.

[10] Ordinance 969, of the city of Fresno.

Pasteurized milk may not exceed 50,000 bacteria per cubic centimeter before pasteurization and not more than 15,000 when delivered to the consumer. Many of the sanitary requirements regarding the production of grade-A milk appear to be stricter than those prevailing in most other cities in California.

All plants distributing grade-A pasteurized milk in Fresno have to be located within the city limits. All such plants are required to pay a fee monthly to the city of Fresno. This fee varies from $50 a month for plants receiving less than 6,000 gallons monthly to $200 a month for plants receiving 45,000 gallons or more monthly. It is provided furthermore that a milk inspector be stationed by the Board of Health in every pasteurization plant, the inspector to devote his whole time to the inspection of such plant.

In the latter part of May, 1931, there was an outbreak of diphtheria in some of the smaller towns in Fresno County. All employees in distributing plants in Fresno were examined and it was found that several of them were diphtheria carriers. As a result, the City Health Officer issued an order prohibiting the sale of grade-A raw milk. This order has not been revoked. As a result no grade-A raw milk has been sold in Fresno since June, 1931.

During the fiscal year 1931–32 some 848 herds with 17,073 dairy cows were tested for tuberculosis, 501 reactors being removed.[11] The number of dairy cows tested for tuberculosis greatly exceeds the number of cows required to furnish market milk to the city of Fresno.

PRODUCTION

The city of Fresno is situated within one of the most important dairy counties in California. In 1931 dairymen in Fresno County produced some 6,099,000 pounds of milk fat, of which less than 877,000 pounds, or about 12 per cent of the county production of milk fat, was sold in the form of market milk. Most of the balance was converted into butter, of which over 7,000,000 pounds were produced in 1931. Only a very small percentage of the dairymen in Fresno County are engaged in the production of market milk or market cream. In October, 1932, the Fresno market-milk supply was obtained from some 66 dairy herds with a combined total of 2,676 cows in milk (table 7).

[11] Letter dated August 8, 1932, from Dr. M. E. McDonald, Chief of the Bureau of Tuberculosis Control, California Department of Agriculture, Sacramento.

TABLE 6

Indexes of Seasonal Variation in the Daily Average of Milk Fat in the Fresno, Los Angeles, and East Bay Milk Sheds

Month	Milk shed			Month	Milk shed		
	Fresno, 1930–1932 (120 shippers)	Los Angeles 1925–1930 (all shippers)	East Bay, 1928–1930 (118 shippers)		Fresno, 1930–1932 (120 shippers)	Los Angeles, 1925–1930 (all shippers)	East Bay, 1928–1930 (118 shippers)
January	89.5	98.9	105.1	July	106.0	99.9	96.3
February	95.1	100.7	106.1	August	106.2	98.8	94.4
March	103.3	99.4	104.6	September	100.5	97.6	94.4
April	110.4	100.9	103.0	October	95.4	98.0	97.7
May	104.7	101.7	99.6	November	93.4	100.8	100.1
June	103.1	101.1	98.3	December	92.4	102.4	100.4

Sources of data:

Fresno: Calculations based upon information supplied by the four distributors.

Los Angeles: Spencer, Leland. An economic survey of the Los Angeles milk market. California Agr. Exp. Sta. Bul. **513**: 101. 1931.

East Bay: Tinley, J. M., and Martin H. Blank. An analysis of the East Bay milk market. California Agr. Exp. Sta. Bul. **534**: 31. 1931.

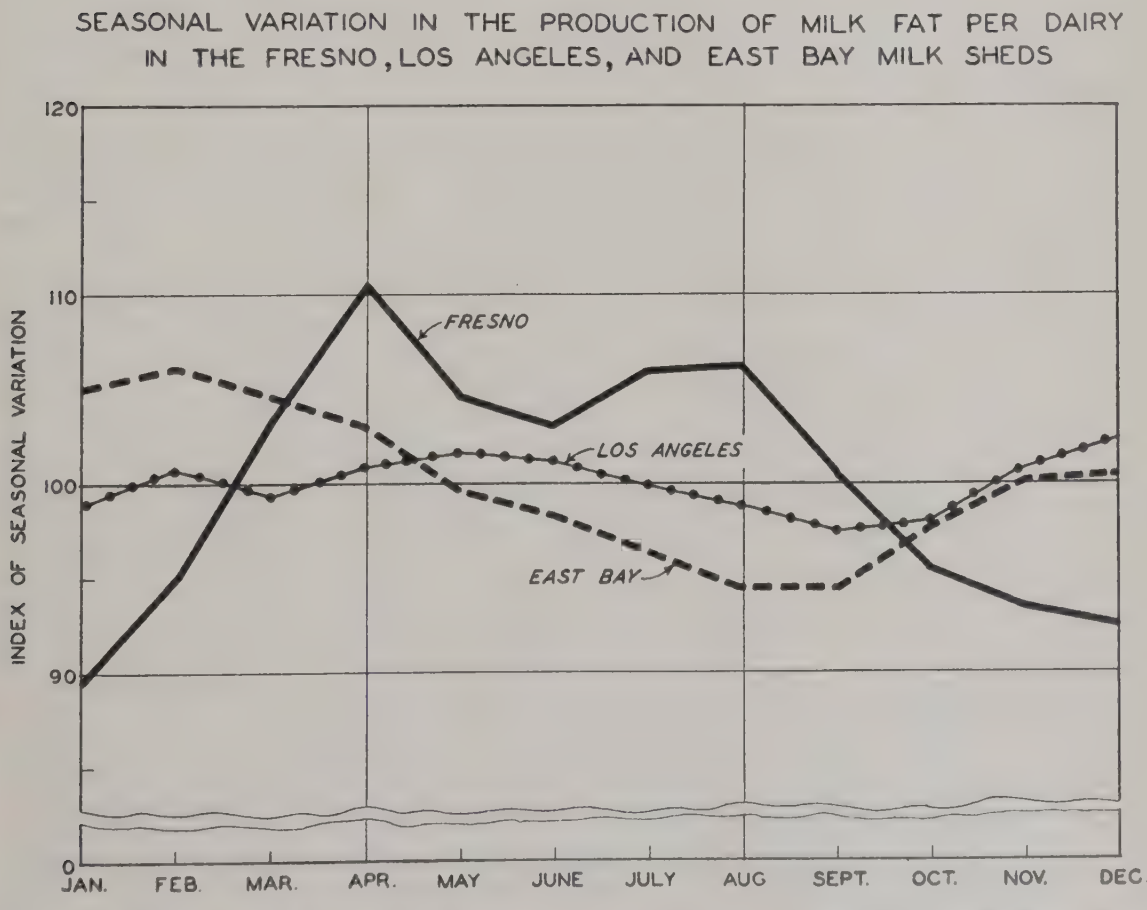


Fig. 2.—There is a greater seasonal variation in the production of market milk in the Fresno market than in the Los Angeles and East Bay cities. (Data from table 6.)

Seasonal Variation of Production.—There is a considerable variation in the production of milk fat in Fresno County, the variation being greater than in the Los Angeles and East Bay milk sheds. (See table 6 and fig. 2.) The months of highest consumption in Fresno are usually September to November, whereas the months of highest production are usually April to August. During the late spring and summer there is thus likely to be a considerable surplus of production. A uniform monthly price for all milk produced does not offer any inducement for dairymen to develop a more uniform monthly supply of milk. It would appear to be desirable in the circumstances to introduce some sort of a basic production plan. Under such a plan each dairyman would have his monthly or daily basic quota determined by his average production during the months when production is more nearly adjusted to consumption requirements. Each individual would be credited with the full monthly base buying price on the quantity of milk supplied as quota milk and a lower price, depending on the amount received, for all surplus milk sent to manufacturing plants. The determination of basic surpluses for individual dairymen could be done by each distributor or preferably by a producers' association. It is desirable that the basis of determination be uniform for all dairymen no matter which distributor they ship their milk to.

Size of Herds.—The average-sized herd supplying market milk to Fresno in October, 1932, was 40 cows. The two largest herds had an average of 128 cows and the two smallest an average of only 9 cows. Two-

TABLE 7

SIZE OF DAIRY HERDS SUPPLYING MARKET MILK TO FRESNO, OCTOBER 31, 1932

Number of cows per herd	Number of herds	Number of cows in group	Average of group
10 or less	2	18	9
11–20	9	153	17
21–30	14	360	26
31–40	19	678	36
41–50	6	257	43
51–60	5	272	54
61–70	2	129	64
71–80	4	303	76
81–90	3	259	86
91–100	0	0	0
100 and over	2	257	128
Total	66	2,676	40

Source of data:
Records of the Health Department of the city of Fresno.

thirds of the herds had less than 40 cows per herd (table 7). The herds supplying market milk to Fresno are much smaller than those in the East Bay and Los Angeles milk sheds, which average 103 and 56 cows per herd respectively.[12]

Years Dairymen Have Shipped Market Milk.—The production of a consistently high-quality market milk in conformance with the rigid sanitary standards of the Fresno City Health Department requires that

TABLE 8

Number of Years Dairymen Have Shipped Market Milk to Fresno

Number of years	Number of dairymen
Less than 1	4
1	5
2	5
3	11
4	2
5	5
6	2
7	5
8 and over	26*
Total	64

* Two dairymen who have shipped milk for over 8 years operate 2 herds each.

Source of data:
Records of the Health Department of the city of Fresno.

dairymen make certain heavy fixed investments and that they have a considerable experience in market-milk production. A rapid turnover of dairymen is undesirable from the standpoint of the city of Fresno and of distributors and also from the standpoint of dairymen who have made the necessary investments. Thirty-eight out of 64 dairymen had been shipping market milk to Fresno for five years and longer; 26 had shipped for eight years and more (table 8).

Location of Herds.—Fifty-six out of the 66 dairy herds supplying market milk to Fresno are located within 15 miles of the city (table 9). These fifty-six herds supplied 5,501 gallons of milk daily in October, 1932, or over 86 per cent of the total milk shipped into Fresno daily to the four distributing plants. All herds are located less than 35 miles from Fresno (fig. 3).

[12] Tinley, J. M., and Martin H. Blank. An analysis of the East Bay milk market. California Agr. Exp. Sta. Bul. 534:35–36. Table 5. 1932.

TABLE 9

LOCATION OF DAIRY HERDS AND MILK SUPPLY OF FRESNO, OCTOBER, 1932

Distance from Fresno, in miles	Number of herds	Amount shipped	Average amount per herd
		gallons	*gallons*
Under 5	18	1,301	78
6–10	26	3,085	119
11–15	12	1,115	93
16–20	2	215	107
21–25	4	360	90
26–30	2	125	62
31–35	2	145	72
Total	66	6,346	96

Source of data: Records of the Health Department of the city of Fresno.

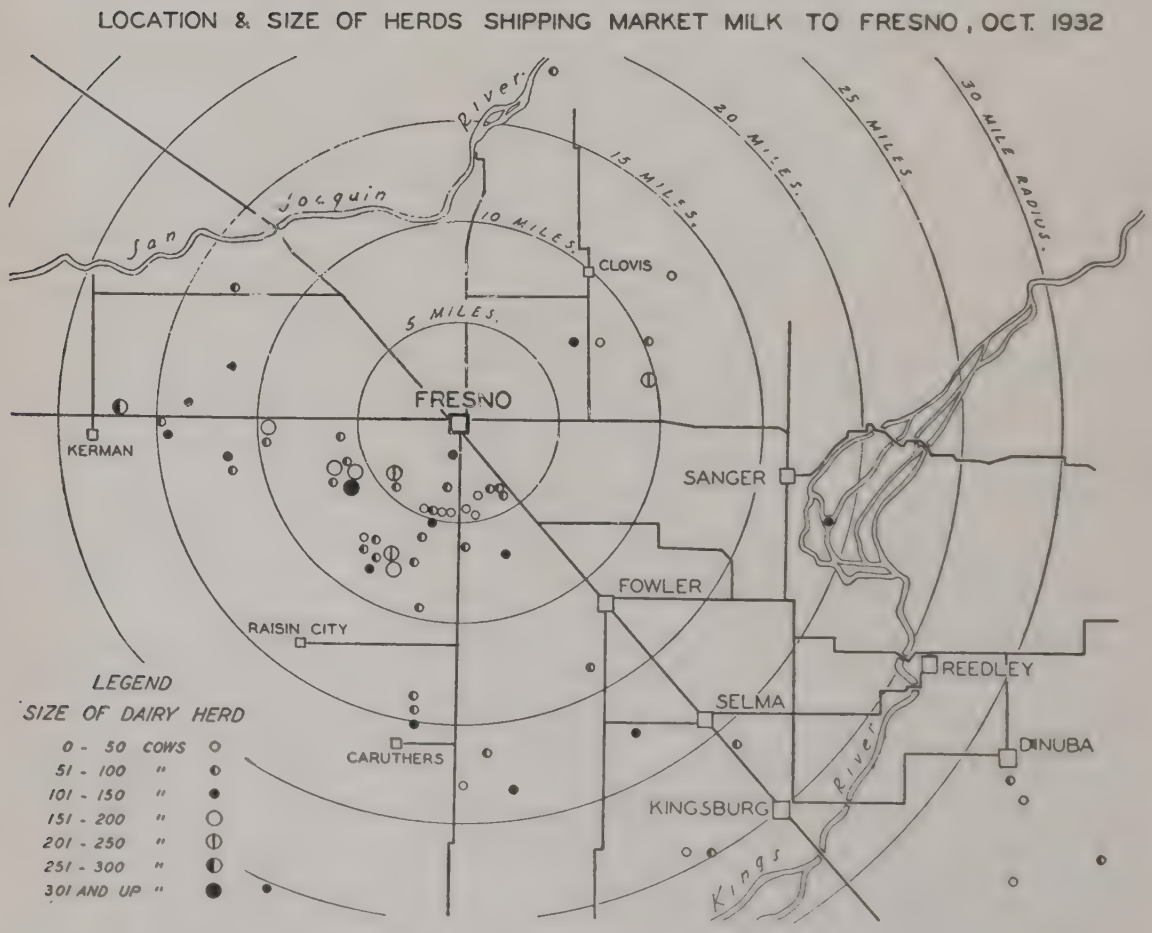


Fig. 3.—The majority of the dairy herds supplying market milk to Fresno are situated within a radius of 15 miles from the city.

It is interesting to compare the location of dairy herds supplying market milk to Fresno and the volume of milk produced by them with similar data for the East Bay cities (table 10). In the latter case less than 6 per cent of the total available supply of market milk was obtained within a radius of 15 miles from Oakland, where most of the plants supplying milk in the East Bay cities are located; over 67 per cent was produced 46 miles and more from Oakland.

TABLE 10
Location of Dairy Herds and Milk Supply of Oakland, June, 1931

Distance from Oakland, in miles	Number of herds	Amount shipped	Average amount per herd
		gallons	*gallons*
Under 15	9	1,965	218.3
16–30	41	7,910	192.9
31–45	5	1,404	280.8
46–60	60	10,118	168.6
Over 60	55	13,094	238.1
Total	170	34,491	202.9

Source of data:
Summarized from: Tinley, J. M., and Martin H. Blank. An analysis of the East Bay milk market. California Agr. Exp. Sta. Bul. **534**: 74. table 23. 1932.

Hauling.—Milk is purchased by distributors in Fresno f.o.b. their plants. A few dairymen haul their own milk to Fresno, but the bulk of the milk is hauled by independent truck owners on a contract basis, the contracts being made between distributors and truck owners. There are 9 hauling routes covered by the same number of trucks. Hauling rates vary between distributors and seem to depend upon the distance to be covered by the truck owner. Until recently hauling rates varied from 2 to 3 cents per gallon, or 20 to 30 cents per 10-gallon can. During the past year (1932) the hauling rates for some dairymen were reduced to 1.5 cents per gallon, or 15 cents per 10-gallon can.

Hauling rates in Fresno seem to be appreciably above those which prevailed in the East Bay cities during June, 1931. Much of the milk supply of the East Bay cities obtained from up to 40 miles from Oakland was hauled for less than 20 cents per 10-gallon can; some milk was hauled over 70 miles for 30 cents a can. In the East Bay study the conclusion was arrived at that the hauling rates appeared to be higher than would be necessary under a more economical system of hauling.[13] A

[13] Tinley, J. M., and Martin H. Blank. An analysis of the East Bay milk market. California Agr. Exp. Sta. Bul. 534:72–77. 1932.

similar conclusion can be drawn relative to hauling rates in the Fresno milk shed, although in the case of the Fresno milk market a lower volume of milk per dairyman may justify somewhat higher rates per gallon for each mile of haul than in the case of the East Bay milk shed.

It is necessary to point out that since milk is hauled to Fresno on a contract basis, distributors do not derive any net income from hauling. It would seem advisable for both producers and distributors to consider the possibility of negotiating new hauling rates with independent truck haulers and also of consolidating several routes. The consolidation of hauling routes would be facilitated by the formation of a dairymen's collective-bargaining association. During the last six months of 1932 extremely low prices prevailed for milk fat. Savings that could be effected by means of reduced hauling rates would contribute to an increase in the net returns to market-milk dairymen or to a reduction in prices to consumers.

BUYING PRICES OF MARKET MILK

For several years prior to March, 1929, dairymen were paid 24 cents a gallon for milk testing 3.6 per cent milk fat or better and 22 cents for milk testing 3.4 and 3.5 per cent. Milk with a test of 3.3 per cent and lower was purchased at a premium over the butter market. In March, 1929, buying prices were increased to 28 cents a gallon for milk testing 3.6 per cent milk fat or better and produced from herds free from tuberculosis. Many dairymen were reluctant to make the necessary adjustments in their dairy herds even for the higher price offered unless they were assured of a market for several years. In order to insure an adequate supply of milk from tested herds, distributors made contracts with individual dairymen during 1929 and the first two or three months of 1930. These contracts varied as to length of time they were to be in operation. They also varied as to prices to be paid and provisions for adjustment of prices. The contracts negotiated towards the end of 1929 and early in 1930, when butter prices had declined appreciably, were usually for lower prices than the earlier contracts.

Early in 1930 it became apparent that there would be an adequate supply of market milk from tested herds. The lower prices paid for manufacturing milk made dairymen anxious to comply with the health requirements in order to sell their milk as market milk. Buying prices for market milk were reduced from time to time during the years 1930 to 1932, although the prices of contract milk were reduced more slowly than milk not bought under contract. During part of 1932 some of the distributors purchased as market milk only a part of the milk supplied

by their patrons who did not have contracts; the balance (about 25 per cent of the production of each individual patron) was purchased practically at manufacturing-milk prices. The other distributors took all the milk supplied by their patrons at market-milk prices. The average prices paid by each of the four distributors for all milk purchased from dairymen during the latter half of 1932, however, were just about equal. These conditions resulted especially during 1930, 1931, and the first half of 1932 in a wide range of prices paid by different distributors and in a wide range of prices received by individual dairymen.

Information was obtained from each of the distributors in Fresno as to the monthly prices paid by them for milk. One distributor listed the actual prices paid to individual dairymen for the years 1930 to 1932. Two distributors listed the average monthly prices paid to all patrons. The fourth distributor supplied information on the total number of pounds of milk fat received monthly and the amounts paid for it. On the basis of this information monthly buying prices were calculated for each distributor for the years 1926 to 1932. A combined price series per pound of milk fat was obtained by weighting each distributor's monthly prices by his proportion of the total purchases of milk fat by all distributors.[14]

The differential between buying prices of market milk and manufacturing milk f.o.b. plants in Fresno is shown in table 11 and figure 4. During the years 1926 to 1928 the differential declined from 21.9 cents per pound of milk fat to 17.2 cents, largely because of a somewhat higher price for manufacturing milk. During the last ten months of 1929 the differential increased to 31.1 cents per pound of milk fat, because of the higher price paid for milk from tested herds. During 1930 and 1931 the average annual differentials between the buying prices of market milk and of manufacturing milk were 29.8 and 27.3 cents per pound of milk fat respectively. In 1932, however, the prices paid for market milk declined absolutely more than the prices of manufacturing milk, the differential in 1932 being almost 10 cents per pound of milk fat lower than in 1931. This differential appears to be somewhat lower than the differentials in the years 1926 to 1928 when milk was not required to be produced from tested herds and when dairymen were not required to meet the strict sanitary requirements existing since March, 1929. The average differential for the last six months of 1932 (13.1 cents a pound of milk fat) was little higher than the average differential for the last

[14] Prices per gallon were converted to a milk-fat basis by dividing by 0.318 on the assumption (borne out to a certain extent by an inspection of distributors' records) that the average milk-fat test on milk purchased from patrons was about 3.7 per cent.

TABLE 11

BUYING PRICES FOR MARKET MILK AND MANUFACTURING MILK, 1926–1932

(In cents per pound of milk fat)

Year	Type of milk	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
1926	Market	76.0	76.0	77.0	76.0	76.0	75.0	77.0	75.0	76.0	73.0	72.0	71.0	75.0
	Manufacturing	52.2	54 2	50.6	49.6	49.4	50.3	50.5	54.2	56.0	55.8	55.6	58 8	53 1
	Differential	23.8	21.8	26.4	26 4	26.6	24.7	26.5	20.8	20.0	17.2	16.4	12.2	21.9
1927	Market	76.0	76.0	77.0	76.0	76.0	75.0	77.0	75.0	76.0	73.0	72.0	71.0	75.0
	Manufacturing	59.8	59.1	56.3	53.4	52.2	52.2	52.4	54.6	58.3	60.0	60.3	60.4	56 6
	Differential	16.2	16.9	20.7	22.6	23.8	22.8	24.6	20.4	17.7	13.0	11.7	10.6	18.4
1928	Market	76.0	76.0	77.0	76.0	76.0	75.0	77.0	75.0	76.0	73.0	72.0	71.0	75.0
	Manufacturing	58.6	55.9	54.4	50.8	52.9	53.7	56.7	59.1	62.7	64.2	61.9	62.6	57 8
	Differential	17.4	20.1	22.6	25.2	23.1	21.3	20.3	15.9	13.3	8.8	10.1	8.4	17.2
1929	Market	76.0	76.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0*
	Manufacturing	57.5	59.0	56.1	55.0	57.5	56.6	57.0	58.6	61.2	61.5	61.1	54 0	57 9*
	Differential	18.5	17.0	30.9	32.0	29.5	30.4	30.0	28.4	25.8	25.5	25.9	33.0	29.1
1930	Market	85.9	86.1	85.8	85.8	83.2	72.0	73.3	72.5	70.9	69 3	69 0	69 1	76 9
	Manufacturing	47.5	49 0	48.3	49.8	47.8	44.7	45.0	48 2	50 4	48.1	44 9	41 7	47 1
	Differential	38.4	37.1	37.5	36.0	35.4	27.3	28.3	24.3	20.5	21.2	24.1	27.4	29.8
1931	Market	65 9	65 4	64.6	61 4	62.2	58.8	61.2	59 4	58 4	57 4	56 9	57 2	60 7
	Manufacturing	32.0	33.3	33.2	29.3	29.5	29.2	30 2	34.1	37.1	38.0	37 6	36 9	33 4
	Differential	33.9	32.1	31.4	32 1	32.7	29.6	31.0	25.3	21 3	19.4	19 3	20 3	27 3
1932	Market	50.7	49.0	49.9	48.0	46.5	45.7	40.5	40.7	41.1	39.1	42.0	42.0	44.6
	Manufacturing	29.1	28.1	26 8	23.9	23 4	21 7	22.8	25 1	26 7	27.2	31 7	33 5	26 7
	Differential	21.6	20.9	23.1	24.1	23.1	24.0	17.7	15.6	14.4	11.9	10.3	8.5	17.9

* March-December average.

† Average price paid for all milk purchased by distributors from producers.

Sources of data:

Market milk: Estimates based upon records of the four distributors in Fresno.

Manufacturing milk: Prices obtained from the Danish Creamery. Three cents have been added to the monthly prices, f.o.b. ranch, furnished by the Danish Creamery, to convert them to prices f.o.b. plant.

six months of the year 1928 (12.8 cents) a year of record high prices for manufacturing milk; it was nearly half of the average differential of the last six months of the previous three years.

Usually buying prices for market milk do not fluctuate seasonally as do buying prices of manufacturing milk.[15] The decline in market-milk

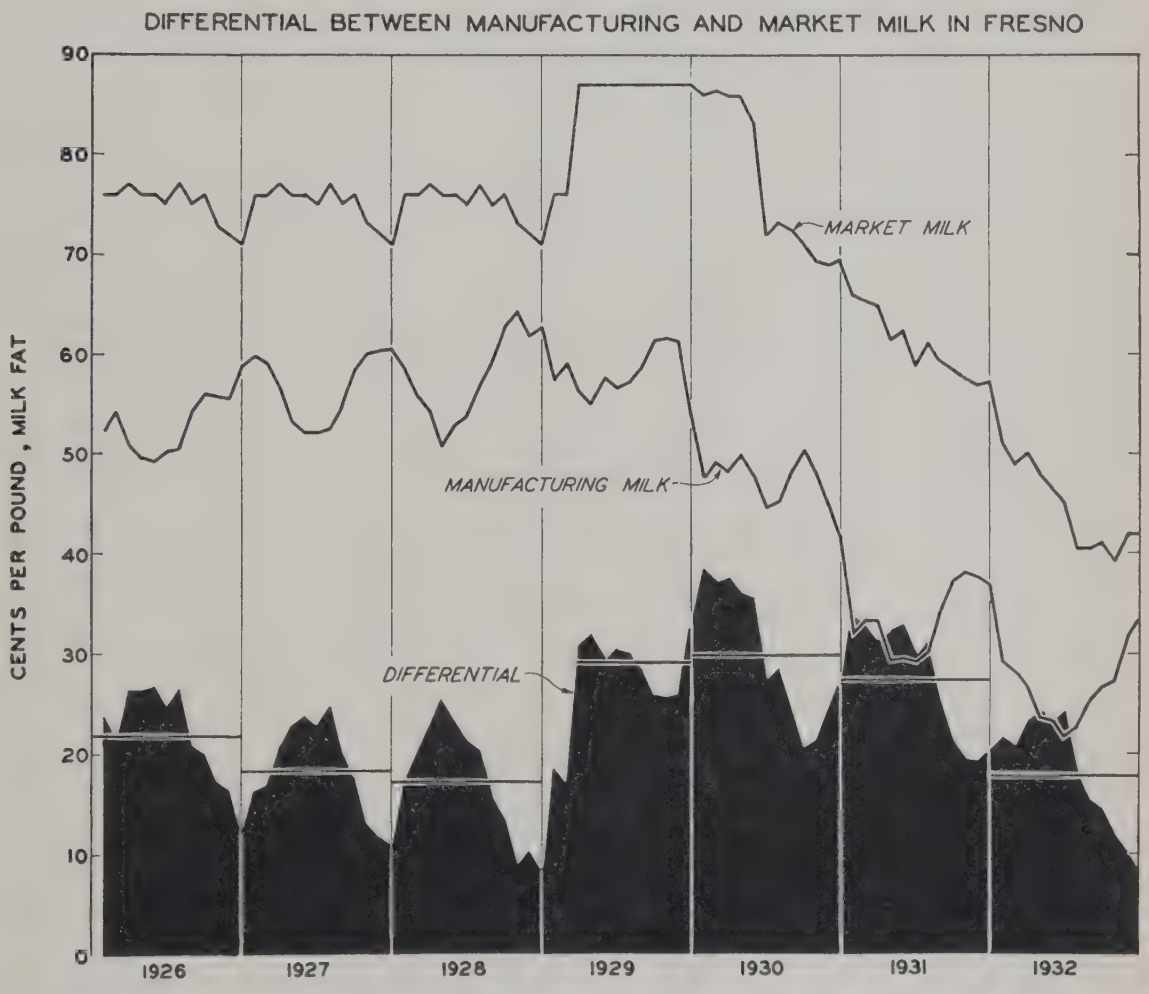


Fig. 4.—The average annual differential of buying prices of market milk over those of manufacturing milk during 1932 was considerably lower than the differential during the three preceding years and somewhat lower than during the years 1926 and 1927.

prices during the last three months of the years 1926, 1927, and 1928 was due not to a change in basic buying prices but to the seasonal decline in the milk-fat content of milk, which resulted in the purchase of more milk at 22 cents a gallon instead of 24 cents a gallon (page 20). There was practically no change in prices for most of 1929 and a part of 1930. Buying prices of market milk, however, declined steadily between May, 1930, and June, 1932.

[15] Tinley, J. M., and Martin H. Blank. An analysis of the East Bay milk market. California Agr. Exp. Sta. Bul. 534:46. 1932.

The reason for this steady decline in price of market milk in contrast to the seasonal variation in prices of manufacturing milk is that manufacturing-milk prices respond more rapidly to changes in business conditions and to changes in volume of production, whereas market-milk prices tend to lag. Manufacturing-milk prices declined to a lower annual average level each year since 1929. Market-milk prices, however, fell less rapidly because of the existence of the numerous contracts at higher prices. The steady decline in market-milk prices since May, 1930, was therefore a process of gradual downward adjustment to bring market-milk prices into closer adjustment with those of manufacturing milk. The downward movement of market-milk prices seems to have been arrested in June, 1932, for during the last six months of that year there was no further decline in market-milk prices; on the contrary there was a slight rise in prices during the last few months of 1932 owing largely to a decline in surplus deductions made by distributors.

In the absence of any marked improvement in general business conditions during 1933, it is probable that manufacturing-milk prices will maintain about the same level during 1933 as during 1932, or perhaps a slightly lower level.[16] It is probable, moreover, that in the absence of any improvement in milk-marketing conditions in Fresno the level of prices for market milk prevailing during the last six months of 1932 will continue for most of 1933. In this event, the average differential between market-milk and manufacturing-milk prices in Fresno for 1933 will be several cents below that for 1932, which was shown above to have been lower than for any year since 1926 except the year 1928.

Although many of the expense factors of production, such as dairy feed and labor, have declined considerably since 1928, the stricter sanitary requirements since 1929 have tended to increase production expenses, especially for those dairymen who had, in good faith, equipped their farms to conform with the stricter regulations during 1929 and the early part of 1930 before prices of building material, machinery, and wages had fallen to any appreciable extent. Several of the distributors stated that many manufacturing-milk dairymen had offered during 1931 and 1932 to equip their farms to supply market milk to Fresno at lower prices than were paid to the market-milk dairymen. Any dairyman who equipped his farm to supply market milk in 1932 would have had a distinct advantage over those dairymen who had equipped their farms earlier, for he could have purchased machinery and building material at much lower prices. Nevertheless, it is extremely doubtful whether the

[16] Wellman, H. R., *et al.* The 1933 agricultural outlook for California. California Agr. Ext. Circular 71: 62. 1933.

prices paid for market milk during the latter half of 1932 would have attracted many manufacturing-milk dairymen, especially if such dairymen were fully aware of the higher fixed and current expenses they would have to incur in producing market milk. Many of the market-milk dairymen interviewed during the course of this investigation stated emphatically that if these prices were continued much longer they would either have to discontinue dairying or change to the production of manufacturing milk. In either event such dairymen would sustain a severe loss on the additional equipment installed by them to produce market milk. Moreover, if a number of market-milk dairymen discontinued production of market milk, the city of Fresno would run the risk of having its milk supplies curtailed, especially since it is extremely unlikely that many manufacturing-milk dairymen will be attracted into the Fresno milk market if the prices which prevailed during the latter half of 1932 are continued for any length of time.

Some increase in buying prices of market milk over those prevailing during the latter half of 1932 would therefore appear to be essential if the market-milk supplies of Fresno are to be maintained.

It would also appear desirable from the point of view of both producers and distributors that buying practices and prices paid to different market-milk dairymen for similar grades of milk be more uniform. Dairymen tend to become dissatisfied if they know that other dairymen are receiving a higher net price for the same quality of milk than they are. Uniform buying prices and uniform methods of disposing of surplus milk can best be insured by the negotiation of prices and buying conditions between a dairymen's collective-bargaining association and distributors. Such an association, while its primary objective is to represent the interests of its members, can nevertheless be of value to distributors by assisting them to maintain uniform resale prices and trade practices. The existence of such an association, moreover, tends to give dairymen a better insight into all the problems affecting the market-milk industry, including the problems of distribution.

DISTRIBUTION

As was shown above (page 12) it is desirable from the point of view of the market-milk industry of Fresno that every effort be made to reduce prices paid by consumers for market milk and to increase prices paid to dairymen. It was shown, furthermore, that a more efficient system of hauling would result in some saving of hauling costs (page 20). Any further decrease in prices to consumers or increase in prices to

dairymen can come only from economies in the system of market-milk distribution. Special efforts were made in this study to ascertain to what extent competition or lack of competition among distributors was responsible for the unsettled conditions in the market-milk industry of Fresno, whether and to what extent the distribution of market milk was profitable to individual distributors, and what improvements, if any, could be made in the distribution of market milk in Fresno.

All business concerns, including market-milk distributors, aim at obtaining a return from the sale of the products handled by them which, after covering their expenditure for raw and finished products purchased and all costs of processing and handling (including depreciation on plant and equipment and administrative expenses), will provide for a return on their capital investment. The difference between the proceeds of sale and the cost of the materials is known as gross profit. Net profit is the difference between gross profit and all the costs of processing and handling. The size of the gross profit for any one concern is a product of the difference between the selling and buying price per unit of product sold (also known as the margin) and the number of units sold. Similarly the size of the net profit of any concern is the product of the net profit per unit (the gross profit per unit less the processing and operating cost per unit) and the number of units sold.

A business concern's gross profit may be increased by an increase in its margin per unit and by an increase in the number of units sold. Its net profit may be increased by an increase in its margin per unit, by a reduction of unit costs, and by an increase in the number of units sold. Unit costs may be reduced by a decrease in the price of any or all of the cost factors of production (labor, fuel, power, equipment, etc.) and by an increase in the number of units handled without a corresponding increase in costs. Conversely gross and net operating profits may be decreased by a decrease in margins per unit, by a decrease in volume sold, and by an increase in the price of some or all of the cost factors of production, or by all three.

If all distributors in Fresno distributed market milk only and always sold market milk of the same quality and in only one size of container, it would be a comparatively easy matter to determine their margins per unit and their unit costs of operation. All of the distributors, however, sell other products besides milk. Some of them do not show in their total proceeds of sales how much is obtained from the sale of milk and how much from the sale of other products. It would also be a very difficult matter to segregate the different costs of processing and handling the various products. Furthermore, it is impossible to obtain detailed oper-

ating statements for all the plants that operated during the period covered in this survey, namely 1926 to 1932.

Much information relative to the efficiency of distribution can be obtained in a more direct although somewhat less accurate manner. Information is available on the number of distributors operating each year, the total volume of milk distributed annually in Fresno, the prices paid to dairymen, the prices paid by consumers, the trend in volume of milk sold wholesale and retail, and the trend in prices of some of the main factors of production. Furthermore an analysis can be made of some of the existing operating practices of distributors. Finally the information so obtained can be compared with such financial statements of distributors as are available.

Number and Capacity of Distributing Plants.—The number of plants distributing milk in Fresno and suburbs at the end of each of the years 1926 to 1932 is shown in table 12. Prior to March, 1929, all plants located

TABLE 12

Plants Distributing Market Milk in the City of Fresno and Suburbs

Year	Firms handling pasteurized grade A		Firms handling all other milk*		Total
	Located within city limits	Located in suburbs	Located within city limits	Located in suburbs	
1926	2		9		11
1927	3		8		11
1928	3		6		9
1929	3	2	0	7	12
1930	4	1	0	5	10
1931	4	3	0	4	11
1932	4	3	0	10	17

* Includes grade A, raw, ungraded raw, and ungraded pasteurized.

Source of data:
Estimates based on records of the Bureau of Dairy Control and the Health Department of the city of Fresno.

in Fresno and its suburbs, which handled milk that complied with the State Pure Milk Law, were permitted to sell milk in the city of Fresno. In 1928, 3 plants distributed grade-A pasteurized milk and 6 distributed other milk (grade-A raw, ungraded raw, and ungraded pasteurized). Two of the 3 pasteurizing plants were situated in the Fresno city limits. In March, 1929, with the passing of the new Fresno city market-milk ordinance all pasteurizing plants situated outside the Fresno city limits and all other plants not handling milk from herds tested for tuberculosis were automatically precluded from selling milk in Fresno.

One new pasteurizing plant was erected in Fresno in 1929 so that there were 3 plants distributing pasteurized milk at the end of that year. In 1930, 2 new pasteurizing plants were erected in Fresno, one of these having operated previously in the suburbs of Fresno. One small pasteurizing plant, however, went out of business during the first half of 1930. At the end of that year there were thus 4 pasteurizing plants located in Fresno. These same plants continued in operation during 1931 and 1932. Up to May, 1931, several of the smaller plants situated in the suburbs distributed grade-A raw milk in Fresno but the total amount distributed by them was probably a very small proportion of the total volume of milk sold in Fresno. The ruling of the Fresno City Health Office prohibiting the sale of grade-A raw milk reduced the number of plants selling milk in Fresno to the 4 pasteurizing plants. The records of the Bureau of Dairy Control, State Department of Agriculture, show an increase since 1930 and especially in 1932 of plants distributing milk outside the city limits of Fresno. In 1930 there were 6 plants, in 1932, 13. Of this number 10 were handling raw milk, most of which was grade-A.

In 1928 over 90 per cent of all the market milk (nearly 1,900,000 gallons) distributed in Fresno and its suburbs was handled by the 2 pasteurizing plants located within the Fresno city limits, and over 80 per cent by only 1 of these. The 3 plants which started operating in 1929 and 1930 expanded their volume of business at the expense of the 2 plants operating in 1928, one of which went out of business in 1930.

The 4 distributors together have experienced a decline in total volume of milk distributed since 1930. In that year they handled 1,620,000 gallons; in 1931 not quite 1,580,000 gallons, and in 1932 only about 1,440,000 gallons. Part of the decline is undoubtedly due to a decline in per-capita consumption.[17] Part may be due to a decline in population. Part is probably due to a loss of business to distributors operating in the suburbs of Fresno. The last "surprise test" inspection of the State District Dairy Inspector made during the latter half of 1932 indicates that the volume of the plants operating outside Fresno has increased appreciably during the past year. Several individuals interviewed stated that many consumers in Fresno purchase milk regularly outside the city limits. While plants not situated in Fresno may not distribute milk in Fresno, there is nothing to prevent consumers from going to the outside plants or to stores handling their milk and buying supplies. It is stated that many consumers desire grade-A raw milk and go outside the city

[17] This has been the case in several other cities in California.

for it. In other cases the lower prices prevailing in the suburbs have attracted consumers inside the city.

Any one of three of the 4 distributing plants could probably handle all the market milk in Fresno. As a matter of fact, one of the existing plants handled more milk in 1928 than the combined volume of 4 plants in 1932. The low volume of milk in relation to capacity handled by each of the plants results in higher unit operating costs than if fewer plants were operating. Not only this but, as will be shown later, the keen competition to maintain or increase volume by the individual distributors has brought into existence many costly trade practices. Such practices, adopted to meet temporary competition, after a while tend to become firmly established and are to some extent responsible for reductions in prices paid to dairymen. In Fresno they seem to have added materially to the unit cost of distribution (see page 45).

Distributors' Margins.—The distributors' margin, as stated above, is the difference between the price received and the price paid for a unit of milk sold. Actual margins may vary from one distributor to another in any one year, or from year to year for any one distributor, for a number of reasons, such as differences in price paid to dairymen, differences in net resale prices (after deduction of special and quantity discounts), volume of milk sold in different containers, volume sold wholesale or retail, and milk-fat content of milk sold. It would be an extremely difficult matter to compute the actual margins for each distributor over a period of time. Average margins for all the distributors, however, can be computed, and these give a fairly accurate reflection of the trend of each individual distributor's margins.

It is customary to compute distributors' margins on a basis of quart bottles of milk because the bulk of the milk distributed is sold in this size of container and margins on other sizes of containers are usually so adjusted as to cover any differences in costs of handling them. In Fresno nearly 84 per cent of all milk distributed in 1932 was sold in quart bottles, about 10 per cent in bulk, and the balance in pints, ⅓-quart, and ½-pint bottles. The volume sold in quart bottles has increased since 1930 and the volume sold in the smaller containers has decreased (table 13). This is probably due largely to the higher proportionate price paid by consumers for the smaller containers.

The average milk-fat test of milk sold in Fresno increased from 3.6 per cent in 1926 to 4.0 per cent in 1931 and 1932. Distributors thus were supplying consumers with a higher quality of milk, as regards milk fat,

in 1932 than they did during the earlier years. This, in the absence of any decrease in prices to producers, would have increased the cost of milk to distributors.

The proportion of milk sold wholesale has increased steadily since the beginning of 1930. During the last six months of 1932 about 85 per cent of all milk sold was wholesale. About the same percentage of the milk sold by each distributor is wholesale. It is thus possible to compute for all four distributors an average margin for combined wholesale and retail sales. Retail margins increased more or less continuously from the beginning of 1929 to June, 1932, since which date they have declined appreciably. Wholesale margins were reduced considerably in June, 1930, but increased up to June, 1932, since which date they have also

TABLE 13

VOLUME AND PERCENTAGE OF MILK SOLD IN VARIOUS CONTAINERS

Container	February, 1931		July, 1931		February, 1932		July, 1932	
	gallons	*per cent of total*	*gallons*	*per cent of total*	*gallons*	*per cent of total*	*gallons*	*per cent of total*
Bulk	13,471	12.27	9,702	10.25	10,364	10.17	11,340	10.37
Quart bottles	87,740	79.90	75,977	80.29	85,205	83.58	91,704	83.87
Pint bottles	4,552	4.14	4,724	4.99	3,327	3.26	3,082	2.82
⅓-quart bottles	2,109	1.92	2,711	2.86	1,407	1.38	1,306	1.19
½-pint bottles	1,942	1.77	1,519	1.61	1,643	1.61	1,911	1.75
	109,814	100.00	94,633	100.00	101,946	100.00	109,343	100.00

Source of data: Records of four distributors in Fresno.

declined. Average margins (retail and wholesale) increased appreciably in March, 1929, when selling prices of milk were increased 2 cents. During the last 7 months of 1930 and the whole of 1931 average margins declined appreciably for three reasons: selling prices were decreased more rapidly than buying prices; the proportion of milk sold wholesale was increasing; the milk-fat content of milk was increased. Average margins increased appreciably during the first six months of 1932 but declined during the last six months (table 14).

While the absolute average margins of distributors were not much greater during 1932 than during the years 1926 to 1928, the margins as a percentage of the prices paid by consumers have increased appreciably. Based on the price of milk delivered to the door of consumers, the percentage margin increased from about 52 per cent during the years 1926 to 1932 to over 67 per cent during 1932. Based on the price of milk paid by consumers to stores, the comparable figures are 35 per cent and 44 per cent respectively.

TABLE 14

DISTRIBUTORS' MARGINS PER QUART BOTTLE OF MILK, 1926–1932

Year	Buying price per pound milk fat	Milk-fat test	Buying price per quart	Selling price			Distributor's margin		Distributor's margin as a per cent of the price paid by consumers		Percentage milk sold		Average distributor's margin on all milk sold, retail and wholesale
				Retail*	Store to consumer	Whole-sale*	Retail*	Whole-sale*	Retail*	Store price	Retail*	Whole-sale*	
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
	cents	*per cent*	*cents*	*cents per quart*	*cents per quart*	*cents per quart*	*cents per quart*	*cents per quart*	*per cent*	*per cent*	*per cent*	*per cent*	*cents per quart*
1926	75.0	3.6	5.8	12	12	10	6.2	4.2	51.7	35.0	50	50	5.2
1927	75.0	3.6	5.8	12	12	10	6.2	4.2	51.7	35.0	50	50	5.2
1928	75.0	3.7	6.0	12	12	10	6.0	4.0	50.0	30.0	50	50	5.0
1929:													
January-February	76.0	3.8	6.2	12	12	10	5.8	3.8	48.3	31.7	50	50	4.8
March-December	89.0	3.8	7.3	14	14	12	6.7	4.7	47.8	33.6	50	50	5.8
1930:													
January-May	85.0	3.9	7.1	14	14	12	6.9	4.9	49.3	35.0	50	50	5.9
June-December	71.0	3.9	5.9	13	11	9	7.1	3.1	54.6	28.2	40	60	4.7
1931	61.0	4.0	5.2	13	11	9	7.8	3.8	60.0	34.5	25	75	4.8
1932:													
January-June	48.0	4.0	4.1	13	11	9	8.9	4.9	68.5	44.5	20	80	5.7
July-October	40.0	4.0	3.4	12	10	8	8.6	4.6	71.7	46.0	15	85	5 2
November-December	42.0	4.0	3.6	11	10	8	7.4	4.4	67.3	44.0	15	85	4.9

* "Retail" applies to milk delivered by distributors to the door of the consumer; "wholesale" applies to milk sold to stores, restaurants, etc.

Sources of data:
Cols. 1, 4, 5, 6, 11, and 12: From records of distributors in Fresno.
Col. 2: From records of the California Dept. of Agr. Bur. of Dairy Control.
Col. 3: Calculated from cols. 1 and 2.
Col. 7: Col. 4 minus col. 3.
Col. 8: Col. 6 minus col. 3.
Col. 9: Col. 7 as a percentage of col. 4.
Col. 10: Col. 8 as a percentage of col. 5.
Col. 13: Average of cols. 7 and 8 weighted by cols. 11 and 12 respectively.

Superficially both retail and wholesale margins in Fresno appear to be higher than in Los Angeles and Oakland (table 15). Such a comparison of margins, however, is unsatisfactory because buying and marketing conditions in Fresno are markedly different from those in Los Angeles and Oakland. In Fresno about 85 per cent of all milk distributed is sold wholesale, whereas in Los Angeles and Oakland the percentages are about 40 and 65 per cent respectively. Moreover, in Fresno each of the distributors handles about the same proportion of retail and wholesale business. In Los Angeles and Oakland, on the other hand, some distributors sell practically all their milk wholesale, whereas others sell

TABLE 15

DISTRIBUTION MARGINS PER QUART OF MILK IN FRESNO, LOS ANGELES, AND OAKLAND, DECEMBER, 1932

City	Buying price		Selling price per quart		Distributors' margins per quart		Per cent milk sold	
	Per pound milk fat	Per quart	Retail	Wholesale	Retail	Wholesale	Retail	Wholesale
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*per cent*	*per cent*
Fresno	42	3.6	11	8	7.4	4.4	15	85
Los Angeles	55	4.7	11	8	6.3	3.3	60	40
Oakland	63	5.4	12	8	6.6	2.6	35	65

Sources of data:
Fresno: From table 14.
Los Angeles: From calculations based on information supplied by California Milk Producers Association.
Oakland: Calculations based on information supplied by distributors in Oakland.

practically all their milk retail. Unit costs of distributing milk wholesale are somewhat lower for a distributor selling all his milk wholesale, than they are for a distributor selling part of his milk wholesale and part retail. Similarly unit costs of distributing milk retail tend to be lower for a distributor selling all of his milk retail, than for a distributor selling part wholesale and part retail.

In Fresno distributors purchase all the milk produced by their patrons. These distributors bear the cost of disposing of milk purchased in excess of what they can dispose of as market milk and market cream. In both Los Angeles and Oakland distributors purchase from producers' associations at the basic buying price only such milk as is required for sale as market milk. The following statement taken from the records of one of the distributors and covering several months during the latter half of 1932, shows how this distributor's margin would have been affected if he had not carried any surplus.

Milk fat purchased from patrons	= 27,300 pounds
Total cost of purchases	=$10,870
Average price per pound	= 40 cents
Surplus sold to manufacturing plant	= 5,000 pounds
Proceeds of sales	=$1,100
Average price per pound	= 22 cents

Loss on milk sold, 5,000×(40 cents–22 cents=18 cents)=$900

If this distributor had purchased only such milk as was required for market-milk and market-cream purposes he would have purchased 27,300 – 5,000 = 22,300 pounds of milk and paid therefor $10,870 – $900 = $9,970, or 44.7 cents per pound of milk fat without altering the financial results of his operations. The price received by dairymen per quart of milk would have been increased from 3.44 cents to 3.85 cents and the distributors' average margin on milk sold both wholesale and retail would have been reduced from 5.16 cents to 4.75 cents a quart. Thus distributors' margins, retail and wholesale, would have compared somewhat more favorably with margins in Los Angeles and the East Bay cities.

Distributors in Fresno pay the same price for milk fat utilized in market cream or cottage cheese as they do for milk fat in market milk. During 1931 the four distributors in Fresno purchased $842,000 pounds of milk fat (table 16). Only 543,000 pounds, or 64.5 per cent of the total milk fat purchased, was sold as market milk; 143,000 pounds, or 17.0 per cent, was sold in market cream. The balance, 156,000 pounds, or 18.5 per cent, was used in manufacturing milk products by the distributors themselves, sold to manufacturing-milk plants, or was lost in the plant. Distributors in Los Angeles and Oakland purchase milk fat for market cream and milk fat for manufacturing purposes at lower prices than they pay for market milk. Data are inadequate to make a numerical comparison of margins per pint bottle of market cream but such evidence as there is indicates that in 1932 the margin on market cream was higher in Los Angeles and Oakland than in Fresno. To the extent to which this was the case distributors in Los Angeles and Oakland could afford to distribute milk on a somewhat lower margin than distributors in Fresno.

It is, moreover, difficult to ascertain to what extent special and quantity discounts are made by distributors in different markets. Such discounts tend to reduce the resale prices below that on the established schedules of prices.

In view of all these facts, it is difficult to say whether or not margins in Fresno are really higher than they are in other cities. It is possible to

state, however, that it would be possible for distributors in Fresno to reduce their margins if the system of distribution were made more efficient.

TABLE 16

RECEIPTS AND DISPOSALS OF MILK FAT BY DISTRIBUTORS IN FRESNO

	1929	1930	1931
Purchases, in pounds			
Producers	785,000	906,000	842,000
Other sources	15,000	12,000	.....
Total	800,000	918,000	842,000
Disposals, in pounds			
Market milk	555,000	537,000	543,000
Market cream	134,000	165,000	143,000
Manufacturing	99,000	156,000	124,000
All other*	12,000	60,000	32,000
Total	800,000	918,000	842,000
Disposals in per cent of total sold			
Market milk	69.4	58.4	64.5
Market cream	16.6	18.0	17.0
Manufacturing	12.2	17.0	14.7
All other*	1.8	6.6	3.8
Total	100.0	100.0	100.0

* Chocolate milk, buttermilk, sold to other milk plants, manufacturing shortage.

Financial Aspects of Market-Milk Distribution in Fresno.—The combined assets of all four distributors in Fresno amounted to some $1,273,600 as of December 31, 1931 (table 17). Current assets accounted for 15.4 per cent of the total; fixed assets less depreciation for 43.0 per cent; goodwill, patents, and trade-marks and stock in other companies for 39.3 per cent; accumulated losses for 2.0 per cent, and deferred charges for 0.3 per cent. Three companies show items for goodwill. The operations for the three years 1930 to 1932, indicate, however, that goodwill is an asset of very doubtful value. It seems to be impossible in the market-milk business to ensure that the volume of business in previous years, which is used to justify the sale of a business for more than the value of its tangible assets, will or can be maintained in future years.

Goodwill in the market-milk industry often attaches to individuals as well as to firms. Individuals who start up in business again may take away all the volume of business that justified the payment of goodwill. It is desirable from the standpoint of the long-time stability of the market-milk industry that firms contemplating the purchase of existing plants in cities in future exercise extreme caution in the valuation of goodwill. The operations of the four distributors during the years 1930 to 1932 resulted in substantial losses. There was thus no money to pay dividends on capital invested in fixed assets, let alone capital invested in goodwill.

TABLE 17

COMBINED BALANCE SHEET: FOUR DISTRIBUTORS IN FRESNO, DECEMBER 31, 1931

Assets			*Liabilities*		
Current		$ 196,400.00	Current		$ 69,500.00
Fixed:			Operating reserves		6,600.00
Land, buildings, and equipment	$578,700.00		Net worth:		
Bottles, cans, cases, and supplies	54,800.00		Issued and subscribed capital or company contract account	$1,174,800.00	
Trucks and automobiles	137,400.00		Surplus	22,700.00	
	770,900.00				1,197,500.00
Less depreciation	$223,800.00				
		547,100.00			
Stock in other companies, goodwill, trade-marks, patents		500,500.00			
Deferred charges		3,600.00			
Accumulated loss		26,000.00			
		$1,273,600.00			$1,273,600.00

About 94 per cent, or $1,197,500, of the combined liabilities of the four distributors was in the form of capital stock or company capital and surplus. The combined net worth of the four companies was 101.7 per cent of capital stock and company capital. The combined surplus was reduced during 1931. The operations for the year 1932 showed a still further decrease of surplus. It is evident that if the conditions existing in Fresno during the years 1930 to 1932 are continued for any length of time, it will seriously undermine the financial integrity of some plants in that city.

Incomes and Expenditures of Distributors in Fresno.—The prices of many of the chief items of expense in production such as labor (wages), automobiles and parts, gasoline and oil, machinery and parts, have declined considerably during the past few years. The big increase in store

sales would usually result in some decrease in delivery costs. If these were the only factors which affect the cost of operation of distributing plants, it could be expected that unit costs of distribution would show some decline since 1928 and 1929 or that profits of distributors have increased.

Several factors, however, have tended to increase per unit costs of distribution, most important of which is a marked decline in the total volume of milk distributed and an increase in the number of distributors. Two of the four plants operating in 1932 also operated in 1929. These two plants in 1929 handled about 150,000 gallons more than the four plants in 1932. The largest plant in 1928 handled just about the same quantity of milk as was handled by the four plants in 1932. The result has been a great decline in the volume per plant. As was stated previously, any one of three plants could have handled all the milk distributed in Fresno during 1932. The low volume handled per plant relative to capacity has tended to increase unit costs to a greater extent than the decline in the prices of many items of expense have decreased them. Furthermore, competition between the various distributors to increase their volume has resulted in the introduction of a number of practices which have increased unit costs still further.

The operating statements of all four distributors for the years 1930 to 1932 were combined in table 18 so as to show the net results of operation by the four distributors during these years. It will be seen that in each of the three years there was a net loss. Two plants showed a loss in 1930 and 1931 and two a small profit. In 1932 all four plants showed a loss. In 1930 the loss of two distributors exceeded the amount set aside for depreciation. In each of the years 1931 and 1932 one distributor incurred a loss in excess of the amount set aside for depreciation.

Sales of all commodities declined in value (1930 to 1932) by 16.2 per cent. During the three years the volume of milk distributed declined 10.6 per cent, wholesale prices per quart 19.6 per cent, and retail prices per quart 9.6 per cent. The decline in the value of sales is not as great as would be expected from the decline in the price and volume of milk. Several of the distributors have increased the range of other dairy products sold through their milk-distributing plant in order to spread operating costs over more commodities (table 19).

The cost of raw and finished goods in relation to sales declined from 1930 to 1932. The higher cost in the first two years was due in large measure to the fact that resale prices of market milk were reduced more rapidly than buying prices.

TABLE 18

COMBINED OPERATING STATEMENT OF FOUR DISTRIBUTORS IN FRESNO

	1930			1931			1932		
	Amount	Per cent of sales	Per cent of total expense	Amount	Per cent of sales	Per cent of total expense	Amount	Per cent of sales	Per cent of total expense
	dollars	*per cent*	*per cent*	*dollars*	*per cent*	*per cent*	*dollars*	*per cent*	*per cent*
Net sales (all commodities)	992,100.00	100.0	.....	988,500.00	100.0	.....	831,200.00	100.0	.....
Cost of goods	651,800.00	65.7	.....	575,000.00	58.2	.....	453,800.00	54.5	.....
Gross profit	340,300.00	34.3	.....	413,500.00	41.8	.....	377,400.00	45.5	.....
Expenses:									
Administration	60,400.00	6.1	14.5	68,100.00	6.9	16.1	53,900.00	6.5	13.7
Manufacturing	130,200.00	13.1	31.2	133,900.00	13.5	31.5	122,900.00	14.8	31.3
Selling and delivery	176,500.00	17.8	42.3	177,600.00	17.9	41.9	173,600.00	20.9	44.1
Depreciation	50,000.00	5.0	12.0	44,600.00	4.5	10.5	42,900.00	5.1	10.9
Total expenses	417,100.00	42.0	100.0	424,200.00	42.8	100.0	393,300.00	47.3	100.0
Net operating loss	76,800.00	7.7	.....	10,700.00	1.0	.....	15,900.00	1.8	.....
Other income (net)	700.00	.....	.....	500.00	.....	.....	300.00	.....	.....
Combined net loss	76,100.00	.....	.....	10,200.00	.....	.....	15,600.00	.....	.....

Source of data: Calculated from records of four distributors in Fresno.

Expenses were grouped under four heads. As the income and expense accounts of the four distributors were prepared in different form, it was necessary to make certain adjustments with the assistance of the accountants of the individual firms in order to get the data in comparable form. In some cases where expenses could not be exactly segregated, approximations were used. While the data in table 18 are not strictly accurate, they nevertheless serve to give a fairly correct picture of the relative importance of the various expense groups. The total expense figures (to the nearest hundred dollars) conform to the combined total expenses as shown in the records of the four distributors.

TABLE 19

APPROXIMATE VALUE OF PRODUCTS SOLD BY THREE* MILK DISTRIBUTORS IN FRESNO, JANUARY–OCTOBER, 1932

Product	Value	Per cent of total sales
	dollars	*per cent*
Market milk	365,400.00	64.5
Market cream	86,900.00	15.4
Buttermilk	15,400.00	2.7
Cottage cheese	14,400.00	2.5
Butter	50,600.00	8.9
All other†	34,000.00	6.0
Total	566,700.00	100.0

* Sales could not be segregated for the fourth distributor.

† Includes evaporated milk, ice cream, powdered skim milk, powdered buttermilk, malted milk, ice cream mix, ice cream, cheese, eggs, Kayo, liquid skim, and chocolate milk.

Source of data: Records of three distributors in Fresno.

The most important expense item was that of selling and delivery, which varied from about 42 per cent of all expenses in 1930 and 1931 to 44 per cent in 1932. Manufacturing expenses accounted for about 31 per cent of all expenses in each of the three years. Administrative expenses varied from 16.1 per cent in 1931 to 13.7 per cent in 1932. Depreciation varied from 10 to 12 per cent. Selling and delivery expenses have declined least in the three years. This was due in large measure to the intense competition of the individual distributors to retain or increase volume. From data obtained from three distributors it appears that labor costs (including salaries) account for about 40 to 60 per cent of all expenses, the average for the three firms being about 50 per cent. Expenses per dollar of sales increased from 42.0 per cent in 1930 to 42.8 per cent in 1931, and to 47.3 per cent in 1932.

All operating costs can be grouped under two general headings, prime and supplementary. Prime costs are the annual cash expenses for wages, repairs, power, and any other expenses which are met out of current income. Supplementary expenses include interest on investment and depreciation. The prime costs have to be met out of current gross income or out of accumulated reserves; otherwise the business will soon find its working capital depleted. All supplementary costs have to be met over a period of time depending upon the lifetime of the various articles of plant and equipment. It is possible, however, for a business concern to operate for several years even if its annual gross income does not cover its supplementary as well as its prime costs. During periods of business stress it is often necessary for business concerns to operate for several years without meeting their supplementary costs.

In view of the fact that the volume of milk distributed in Fresno has declined appreciably since 1929, whereas the number of plants has increased, most of the distributors in Fresno are fortunate in that they were able to meet at least a part of their supplementary costs, namely depreciation. Distributors are no more justified in claiming that the annual returns from their business must under all circumstances cover both prime and supplementary costs than are dairymen. That most of the distributors in Fresno covered at least part of their depreciation costs is due to the fact that they were able to pass on to dairymen most of the decline in retail prices of market milk.

Delivery.—It was pointed out above that selling and delivery costs, including depreciation, accounted for over 40 per cent of the total operating expenses of the four plants in each of the three years, 1930 to 1932. Administrative and manufacturing efficiency is an internal matter for each plant, and it is to be expected that plants will exercise every care to keep expenses for these operations down to a minimum. Selling and delivery expenses, however, are governed to a large extent by conditions in the market, over which distributors as individuals have less control. These conditions include such factors as concentration of population, volume of milk sold wholesale and retail, services rendered to customers, and keenness of competition.

Data are not available as to the proportions of the total volume of milk sold wholesale and retail prior to 1930. One of the distributors who has had long experience in the Fresno milk market estimates that roughly 50 per cent was sold wholesale during the years 1926 to 1929. The proportion of milk sold wholesale in Fresno up to 1929 seems to have been higher than in other milk markets in California such as Los Angeles, San Francisco, and Oakland, although prior to May, 1930,

there was no difference between store and retail prices in Fresno. The reason advanced for the comparatively high proportion of wholesale business in the latter city was that Fresno has for many years had a big transient population, especially during the fruit-picking season. Most of the transient laborers during the fruit-picking season purchase their milk from stores or with meals at restaurants.

Prior to 1930 over 70 per cent of the milk distributed in Fresno and surrounding territory and practically all the wholesale business was in the hands of one firm. In 1930 two important competitors came into the market and actively solicited business. One of the new competitors concentrated on store trade and the other in the beginning on retail trade. The older firm in an attempt to retain its wholesale trade agreed to a reduction of its prices to stores to 4 cents below retail prices; store prices of milk to customers were at the same time reduced to 2 cents below retail delivered prices. Corresponding changes were made for milk sold in pint, ½-pint, and ⅓-quart bottles. The other three distributors adopted similar price differentials. It is important to note that the price differentials introduced in Fresno in 1930 were similar to those already existing in Los Angeles and the San Francisco Bay cities.

The differential between the store and retail delivered prices caused a large number of consumers, many of whom had experienced a decline in purchasing power, to purchase their milk supplies from stores. It is estimated that by October, 1930, wholesale sales exceeded 60 per cent of the total volume of milk sold. The proportion gradually increased until in October, 1932, over 85 per cent of all milk sold was wholesale (table 20). It is probable that the trend of sales through stores is still

TABLE 20

PERCENTAGE OF TOTAL VOLUME OF MILK DISTRIBUTED WHOLESALE AND RETAIL IN FRESNO

Date	Wholesale	Retail	Date	Wholesale	Retail
	per cent	*per cent*		*per cent*	*per cent*
1929*	50.0	50.0	February, 1932	79.6	20.4
October, 1930*	65.0	35.0	July, 1932	84.7	15.3
February, 1931	71.2	28.8	October, 1932	85.5	14.5
July, 1931	81.6	18.4			

* Estimated.

Source of data: Records of four distributors in Fresno.

increasing. There was a slight decline of store sales between July, 1931, and February, 1932.

About 72 per cent of milk sold wholesale, or 61 per cent of all milk distributed, goes to retail stores, 15 per cent to hotels and restaurants,

8 per cent to various public institutions, and the rest to drug stores, soda fountains, bakeries, meat markets, billiard saloons, etc. Most of the milk sold to stores is in quart and pint bottles, quart bottles predominating. Bulk milk (milk in cans) is sold to hotels, restaurants, and public institutions such as schools and hospitals. One-third-quart and ½-pint bottles are sold mainly to hotels and restaurants. Table 13 gives the percentages of all milk sold in various containers. Bulk milk accounts for over 10 per cent of all milk. This percentage is somewhat greater than in Los Angeles and the East Bay cities.[18]

TABLE 21

Number of Distributors in Fresno Delivering Milk to Grocery Stores and Restaurants, June, 1932

Number of distributors delivering	Stores*		Restaurants and hotels	
	Number	Stops†	Number	Stops†
4	15	60	....	....
3	38	114	1	3
2	86	172	7	14
1	134	134	155	155
Total	273	480	163	172

* Each unit in a chain system is regarded as a separate store.

† Each store to which milk is delivered is regarded as a separate stop. Each time milk is delivered to a store, a "stop" is regarded as a separate delivery.

Source of data: Computations made by a distributor in Fresno.

The large proportion of milk sold to stores and restaurants warrants an examination of the service rendered by distributors to these groups. In most cities in California stores are required to purchase milk in quantities of a case (12 quarts) or more at a time. As a rule each store is served by only one distributor. Most stores have only one delivery of milk a day and are expected to take a sufficient quantity at each delivery to care for their day's sales. Stores handling milk are expected to have proper refrigeration so as to preserve the quality of milk until it is sold to consumers. The quantity sale of milk to stores generally is considered to result in sufficient saving over retail delivery to justify a price to stores of 4 cents a quart below retail prices.

In Fresno 15 stores received milk in June, 1932, from all four distributors, 38 stores were served by three distributors, and 86 by two (table 21). The remainder of the stores, 134 in number, were served by only one

[18] Spencer, Leland. An economic analysis of the Los Angeles milk market. California Agr. Exp. Sta. Bul. 513:45, table 23, 1931; and: Tinley, J. M., and Martin H. Blank. An analysis of the East Bay milk market. California Agr. Exp. Sta. Bul. 534:83, table 25. 1932.

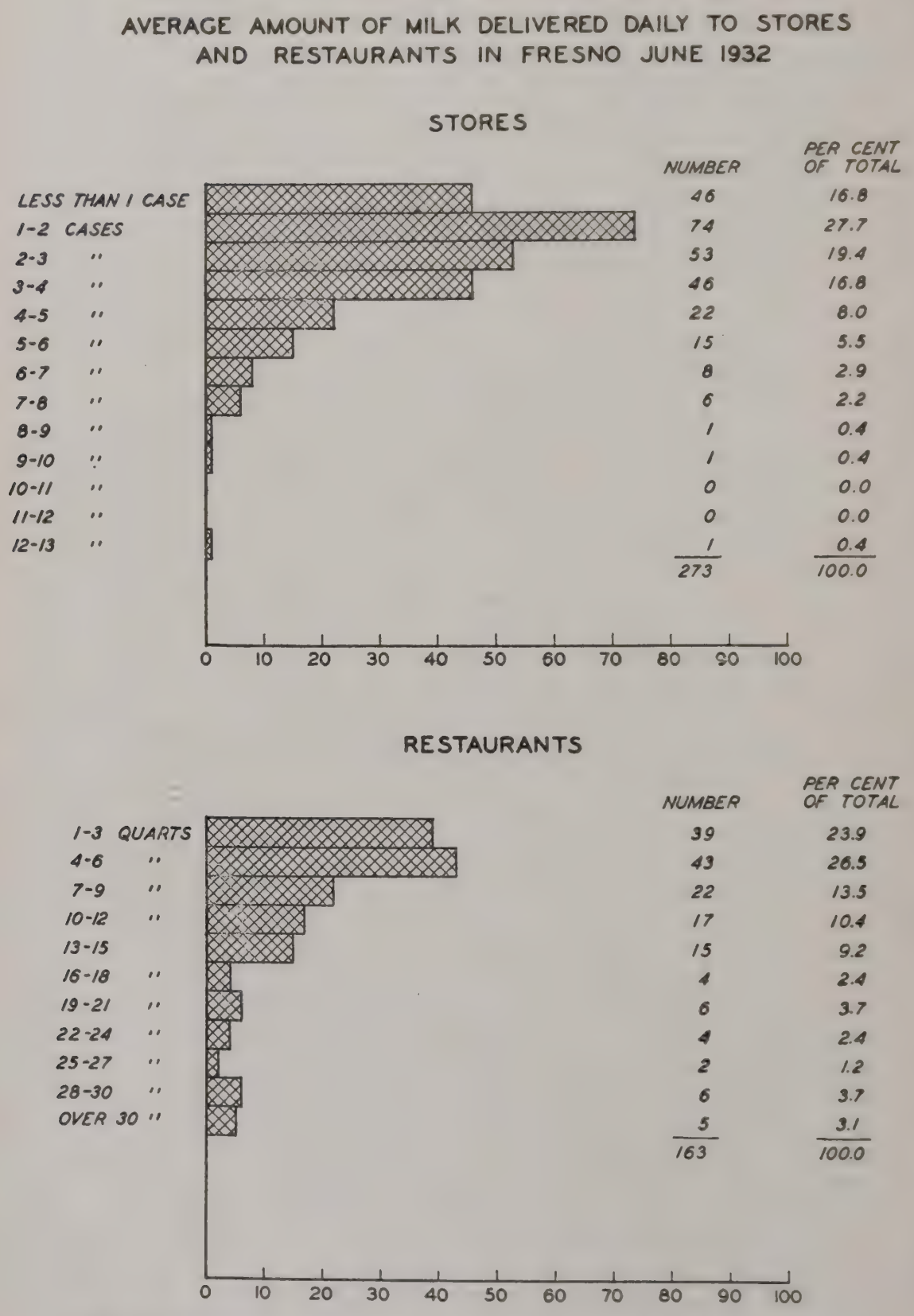


Fig. 5.—Many stores and restaurants purchase very small quantities of milk a day from distributors.

distributor. Over half of the stores received milk from two or more distributors. There were fewer instances of duplication in serving hotels and restaurants. One restaurant received milk from three distributors, 7 from two distributors; the remainder, 155, were served by only one distributor. There were only 172 separate stops for 163 restaurants.

TABLE 22

Number of Distributors in Fresno Serving Milk to Certain Selected Stores

(Selected days in July and August, 1932)

Store	Number of distributors delivering	Number of deliveries by all distributors per day	Number of quarts delivered by all distributors	
			Total per day	Average per delivery
A	3	7	120	17.0
B	4	9	114	13.0
C	3	5	66	13.0
D	1	3	36	12.0
E	1	4	48	12.0
F	3	6	72	12.0
G	2	6	72	12.0
H	1	7	75	11.0
I	3	6	60	10.0
J	4	10	102	10.0
K	3	7	72	10.0
L	3	5	48	10.0
M	4	9	84	9.0
N	4	6	54	9.0
O	2	4	34	8.5
P	3	4	30	7.5
Q	3	5	37	7.0
R	2	4	24	6.0
S	1	4	24	6.0
T	3	3	18	6.0
U	4	6	36	6.0
V	2	4	20	5.0
W	3	6	32	5.0
X	2	4	20	5.0
Y	1	5	24	5.0
Z	1	4	6	1.5

Source of data: Records of distributors in Fresno.

Many of the stores and restaurants received very small quantities of milk a day. Forty-six, or 16.8 per cent of all the stores, took less than 1 case (12 quarts) of milk a day; 74 stores took between 1 and 2 cases, and 53 between 2 and 3 cases (fig. 5). In other words, nearly two-thirds of the stores took less than 3 cases of milk a day each; 39, or 23.9 per cent

TABLE 23

QUANTITIES OF MILK AND CREAM DELIVERED PER DAY TO CERTAIN SELECTED STORES AND RESTAURANTS

(Selected days in July and August, 1932)

Purchaser	Number of deliveries	Milk		Cream		All other
		Quarts	Pints	½ pints	¼ pints	
Store A	1	36	5	9	9	
	1	6	0	0	0	
	1	12	0	0	0	
	1	12	0	0	0	
	1	8	0	8	2	1 gallon buttermilk
	1	....	0	0	0	
	6	74	5	17	11	
Store B	1	12	0	0	0	
	1	0	0	3	0	
	1	6	0	0	0	
	1	4	0	0	0	
	1	6	0	0	0	
	5	28	0	3	0	
Store C	1	6	0	1	0	1 quart cottage cheese
	1	6	0	0	1	1 gallon buttermilk
	1	1	2	1	0	2 quarts cottage cheese
	1	10	2	0	1	1 gallon buttermilk
	4	23	4	2	2	
Store D	1	2	0	0	0	1 quart cottage cheese
	1	2	0	0	0	
	1	2	0	0	0	1 quart cottage cheese
	1	0	0	2	0	
	4	6	0	2	0	
Store E	1	12	0	0	0	
	1	6	0	0	0	
	1	12	0	0	0	
	3	30	0	0	0	
Store F	1	6	0	0	0	
	1	4	0	0	0	
	1	6	0	0	0	
	1	6	0	0	0	
	1	2	0	0	0	
	5	24	0	0	0	
Restaurant 1	1	6	0	0	0	
	1	6	0	0	0	
	1	12	0	3	0	
	3	24	0	3	0	

Source of data: Records of distributors in Fresno.

of the restaurants, took under 3 quarts of milk a day;[19] 43 took between 4 and 6 quarts; and 22 between 7 and 9 quarts. Nearly two-thirds of the restaurants took less than 9 quarts a day.

Many of the stores and restaurants have inadequate cooling facilities and take minimum quantities of milk at a time. If their supply of milk runs out they merely call up one or another of the distributors supplying them and a special delivery is made. Table 22 shows the number of distributors serving selected stores and the total and average quantity of milk per individual delivery. Many of the stores are served 8, 9, and 10 times a day; in many instances the number of quarts per delivery is below 6. As a rule stores receive cream, buttermilk, cottage cheese, and other dairy products as well as milk. The total purchases for one day are shown in table 23, for several stores and one restaurant which purchased their supplies from only one distributor.

The state of affairs described above, which greatly increases the unit cost of delivery, has come about as the result of unrestricted competition between the four distributors. Each firm in an effort to build up volume of sales is continuously approaching retail grocery stores and restaurants, especially those served by only one competitor, to carry some of their milk or to transfer their patronage. In order to win or retain such patronage each distributor must stand ready to deliver milk or cream at any time a store or restaurant may desire it. Moreover, most of the distributors allow some stores special discounts on the prevailing prices. Several of the distributors show substantial sums in the profit and loss statements for discounts allowed. Some of this undoubtedly was for discounts on milk. Another weakness of the trade conditions as they exist in Fresno is that losses from bad accounts may be and probably are increased. Distributors fearing to lose a customer are loath to press for the payment of overdue accounts.

These unsatisfactory conditions have come about through competition, and yet it is evident that the relative volume of trade handled by the various distributors has not changed much during recent months. If distributor A succeeds in taking away some business in store X from distributor B, the latter succeeds in taking some business from distributor A in store Y. Both producers and consumers would benefit if distributors in Fresno put an end to this unbeneficial competition.

Bottle Losses and Expense of Collection.—All four distributors stated that their losses on bottles were extremely high. Figures supplied by two of the distributors bear this out. In addition, the collection of

[19] Much of this in pint, ½-pint, and ⅓-quart bottles.

bottles is an expensive and unsatisfactory undertaking. Three of the distributors depend upon a bottle exchange for the collection of bottles from stores; the fourth distributor makes his own arrangements for such collections. Each distributor calls for his own bottles delivered to his retail customers.

The expense of collection and the high bottle losses arise out of the fact that the distributors do not have a universal store bottle and do not require customers purchasing milk from stores to make a deposit on bottles. As a result there is no incentive on the part of the customer to return bottles purchased by them.

Most of the larger cities in California have found that the introduction of a universal store bottle with a deposit charge decreased the cost of collection and bottle losses appreciably. The two following statements bear this out:

"....We have found it [the universal bottle] to be a great help in reducing an excessive bottle expense, both in quantity of new glass bought and the bottle-exchange costs."[20]

"Of course, just the use of a [universal] store bottle would cut down this loss tremendously, as in the case of the Alameda County Milk Dealers' Association in 1922 when they all adopted a store bottle with a uniform deposit charge. The number of bottles handled through the exchange dropped from over 100,000 a month to less than 30,000 a month."[21]

The use of a universal store bottle handled by an association to which all distributors belong has several other advantages besides the decrease in bottle expense. Harmony among dealers is promoted as a result of their working together. They are thus able to build up a better trade ethics. The existence of a dealers' association handling a universal store bottle tends to discourage new competitors from entering the field. New distributors entering a market frequently attempt to build up a volume of business by price-cutting. They would either have to join the association and agree to abide by established trade practices or they would be subject to higher expenses of bottle collection. If a trade-marked universal store bottle strays to other parts of the state, it would be returned by the bottle exchanges operating in other cities, whereas a privately owned bottle would not. This would be an important consideration in Fresno, which has a very large transient population during certain times of the year. By having a universal store bottle it is easier

[20] Excerpt from a statement made on November 18, 1926 at the Pacific Slope Dairy Show by Mr. Harry Walsh, at that time Secretary of the Southern California Milk Dealers' Association.

[21] Extract from a letter dated January 11, 1932 from Mr. W. H. Moebus, at one time manager of the Bottle Exchange in the East Bay cities.

to introduce a deposit charge. Individual distributors could not do this. After a while the public comes to recognize the universal store bottles as a mark of quality.[22]

Retail-Store Margins.—In December, 1932, the following was the distribution of the money paid by the consumer for a quart bottle of milk:

		Service performed
Store margin	2.00 cents	Daily storage and sale of milk. Sometimes delivery to consumer.
Distributor's margin	4.39	Receiving, pasteurizing, bottling, and delivery.
Producer's price	3.61	Production and delivery to distributor's plant.
Paid by consumer	10.00 cents	

In a large number of cities in the United States, stores have a 2-cent spread between the buying and selling price per quart. This spread has existed in Fresno for a long period of years. It is important to realize, however, that in many of the other cities in the United States the proportion of milk sold through stores is far smaller than in Fresno. In this city, while the prices received by producers and the wholesale margins of distributors have declined since 1929, the absolute store margin per quart bottle has remained the same. On a percentage basis (based on the price paid by stores) the store margin has actually increased. In 1929 stores paid 12 cents a quart for milk and sold it for 14 cents—a spread of 16.66 per cent. During the last six months of 1932 stores purchased milk at 8 cents a quart and sold it at 10 cents—a spread of 25 per cent. Moreover, the volume of milk handled by stores has increased greatly since 1929. Several operators of grocery stores interviewed during the course of this study stated that they handled several times more milk in 1932 than they did in 1929. Many other comodities are handled on much lower margins than market milk. In fact, several operators stated that the margin on many goods handled by them was so low that they depended largely on the margin on milk and some other commodities to meet their operating costs.

From a point of view of comparative service rendered by the three agents—dairymen, distributors, and retail stores—in getting milk to the consumer, it would seem that the store margin on milk is out of line with the margins and prices received by the other two groups. Producers receive only 3.61 cents a quart, which price has to meet all the costs incurred in producing and delivering milk to the plants of distributors.

[22] From a letter dated January 11, 1932, from Mr. W. H. Moebus.

Distributors receive 4.39 cents for pasteurizing, bottling, and selling milk to stores and collecting empty bottles. Stores receive 2 cents for receiving and selling milk, much of which is sold for cash. They have a daily turnover, with no losses through spoilage, and milk is sold in the same containers in which received.

The percentage margins taken by retail stores on different commodities vary considerably. As a rule margins are lowest on commodities which comply with the following conditions: (1) rapid turnover (daily for commodities like bread and milk), (2) very small investment in stocks of that commodity, (3) minimum of loss through spoilage, (4) constant volume of sales from day to day, (5) the commodity must be one that attracts customers to the stores, (6) minimum of credit losses and (7) minimum of service and investment for handling. Market milk complies with practically all these requirements, and yet the margin on which it is handled by stores is wider, relatively, than on many other commodities which do not comply with these conditions.

Any reductions in such margin, however, will be strenuously opposed by many retail-store operators, as they have adjusted their operations to this margin. Many retail stores could show that their earnings from the sale of milk are vital to their remaining in business. On the other hand, it is equally important if the consumption of market milk is to be stimulated that every effort be made to reduce the prices consumers pay for milk. Moreover, if the consumers in Fresno are to be assured of an adequate supply of milk, it is essential that dairymen receive a price which will induce them to produce the high quality of milk required under city health regulations.

It is considered that those in the market-milk industry in Fresno would be justified in making an effort to induce retail grocery stores to handle market milk on a narrower margin. In this connection, it is interesting to note that during 1932 the spread between the price paid by stores and the price at which milk was sold to consumers was reduced from 2 cents to 1 cent in Los Angeles. In the East Bay cities consumers purchasing 3 or more quarts of milk at a time paid only 9 cents a quart, the store paying 8 cents a quart. All milk sold in quantities of 3 quarts or more at a time is thus handled on a 1-cent margin.

Under conditions described above it is evident that wholesale delivery costs in Fresno are much greater than in cities like Los Angeles and Oakland, where stores as a rule are served by only one distributor; where deliveries are made only once or at most twice daily; and where stores are required to purchase a minimum of one case (12 quarts) of milk a delivery. It would seem most desirable that distributors use every

effort to reduce the amount of service rendered in delivering milk to stores. It seems most regrettable that distributors in Fresno, while they have all realized and deprecated the unsatisfactory conditions in the distribution of market milk, have been so tardy in bringing about improved conditions and eliminating undesirable trade practices. Each individual distributor has hesitated to make suggestions for the improvement of delivery methods, fearing that any suggestion made may be used by his competitors to injure his business with stores and restaurants. As a result, matters have been allowed to drift to the disadvantage of producers and consumers and even of distributors themselves.

The Problem of Distribution.—One of the most serious problems facing agriculture at the present time is that of more economical methods of distributing agricultural products. This applies to other branches of agriculture as well as to milk marketing. In most instances the farm prices have fallen absolutely and relatively to a greater extent than wholesale or retail prices. Put in another way, costs of distribution have not declined to nearly the same extent as prices paid to producers.

The reasons for the failure of these costs to decline proportionately to prices of farm products vary for different industries. Relatively rigid railroad and other transportation rates, high labor costs, excess of productive and distributive capacity over volume being handled with a resultant increased unit cost of distribution, and inefficient and uneconomic methods of handling are some of the chief causes. Furthermore, margins of processors or handlers of agricultural products tend to become established on a fixed absolute basis (during periods of stable price levels). During periods of falling price levels these same processors, because of their relatively small numbers as compared with producers of agricultural commodities and because all proceeds of sales pass through their hands, are able, for a time at least, to resist any decrease in their absolute margins.

Some of these conditions obtain in the market-milk industry. The problem of any further decreases in prices to consumers or increases in prices to producers thus becomes a problem of more efficient and less costly methods of distribution.

It is necessary here to distinguish between inefficiency of the whole system of distribution and inefficiency of individual distributors. It is probable that while the system may be most inefficient and uneconomical, individual plants may be and often are operating with the utmost internal efficiency. It is also necessary to point out that all the responsibility for the inefficiency of a system cannot fairly be placed upon the indi-

viduals operating under that system. Such individuals may be affected adversely because of the inefficiency of a system just as much as other groups. For these reasons it is desirable to concentrate upon an analysis of means of improving the system as a whole. Such improvement in the market-milk industry may and often does require the united efforts not only of distributors but of all other interested groups, including producers and consumers.

There is a widespread belief that free competition in distribution is necessarily in the best interests of consumers, that the freedom of any person or firm to enter the market necessarily means low distribution costs. While this may be true over a long period of years, temporarily (maybe for several years) the results of free competition may be just the opposite. Experience has shown that for certain types of service the public interest is served best by limitation of the number of firms or organizations supplying those services. For this reason such services as water supply, electricity and gas supply, railroads, street cars, and garbage removal have been made public utilities. Standardization of methods of operation and type of service characterize most of those public utilities.

This study and other studies made in different cities in California and the United States indicate that free competition in the distribution of market milk does not under all conditions work to the best interests of producers and consumers. In the long run free competition in any industry is assumed to result in the elimination of inefficient operators and plants and to stimulate the remaining operators to function as economically as possible. Under such conditions most of the savings effected by improved and more economical methods of operation are passed on to consumers in the form of lower prices, thus resulting in increased consumption.

In the short run, however, free competition in an industry may have results which are the opposite of the long-run effects. A new operator who enters a market or industry appears to base his calculations as to his probable costs of operation and return on investment, not so much on the conditions as they will come to prevail after the new plant has been erected as on a basis of conditions prior to his entrance into the market. The new conditions may be and frequently are greatly different from the earlier conditions. Competition among the new and older plants to maintain or increase volume of business may result in price-cutting and trade practices which may make it difficult for both the new and the older plants to operate economically.

Conditions after the entrance of the new plant may be further complicated if consumption and therefore the total volume handled by all the plants declines as a result of unfavorable business conditions such as have prevailed since the end of 1929. After a while all the plants may agree to eliminate price-cutting and to work on a margin which may enable all the plants, both the old and new, both efficient and inefficient, to meet operating costs and to secure a return on invested capital. The increased operating costs as a result of decreased volume consumed and the increase in the number of plants may result in the establishment of new margins as high or higher than before, notwithstanding the possible introduction of more economical methods of operation or a decline in the prices of some of the cost factors of production. Such conditions almost inevitably result in the attraction of still more plants into the market.

Trade agreements which aim at establishing margins on a basis which will enable all operators, inefficient as well as efficient, to continue in operation tend to curb the free working of competition for a time. Eventually, but perhaps not for many years, such unsound trade agreements will break down and free competition will again become established. Furthermore, even if there is no impediment to the working of free competition, inefficient operators and plants may not be eliminated rapidly. As was pointed out above (page 39), an inefficient operator may continue in business for several years even if the returns from his operations do not cover both current cash costs and depreciation on plant and equipment. Moreover, while an operator may be forced out of business, the physical plant may continue to be operated by a new owner.

The conditions relative to competition above described seem to have obtained in Fresno as well as in many other milk markets since 1929. While there have been other factors which led to the entrance of new distributors into the Fresno milk market since 1929, the relative profitableness of distribution in that market prior to 1929 was undoubtedly one of the prime reasons. Since 1929 the number of plants operating in Fresno has increased and the volume of milk handled per plant has declined to such an extent that distributors' margins, while they are about as wide as in 1929, are no longer adequate to cover operating costs including depreciation and provide for a return on investment. The firms that entered the market since 1929, have found that the anticipated profits have not been forthcoming. The competition resulting from an increase in distributive capacity has been one of the chief factors contributing to inefficiency in distribution and high unit costs of distribution. Conversely, a decrease in the number of distributors would lead,

under existing conditions, to an elimination of inefficient trade practices and a reduction of unit costs of distribution.

It would appear to be desirable in the interests of more efficient operation for the four distributors in Fresno to agree to the elimination of one or more of the existing plants and to compensate in some equitable manner the owners of the plants eliminated. This would enable the remaining distributors to decrease operating expenses and to work on a narrower margin. Such a step, however, in the absence of any other forms of restriction, would not prevent the entry into the market of new distributors.[23] For this reason the four distributors are adverse to taking any steps toward consolidation.

It does not appear that the problems of the market-milk industry in Fresno will be solved by allowing numbers of dairymen, who can comply with the necessary sanitary requirements, to distribute grade-A raw milk. *It is not the purpose of this study to analyze the relative food value and sanitary merits of grade-A raw and grade-A pasteurized milk.* It is necessary, however, to point out the probable economic consequences of such a step.

The first few dairymen who equip themselves to distribute raw milk will possibly benefit for a time. Eventually, however, as more and more dairymen undertake to distribute their own milk, competition among the various raw-milk producer-distributors themselves and between them and distributors of pasteurized milk, who will not unreasonably make every effort to safeguard their business, will result in conditions which will be disadvantageous to the Fresno market-milk industry, including the raw-milk producer-distributors. Price-cutting and the introduction of undesirable trade practices may and probably will result immediately in a milk war. Such practices together with the increase in distributive capacity, will eventually result in higher unit costs for all distributors. One or more of the existing distributors of pasteurized milk may be forced into liquidation, but as was pointed out above this does not mean that the operation of the physical plants will cease.

Furthermore, it is improbable that even under the most favorable conditions, all the milk distributed in Fresno will be grade-A raw milk.[24] It is unlikely, moreover, that the opening of the Fresno market to raw milk will greatly increase the total volume of milk distributed. There-

[23] In spite of the fact that the four distributors in Fresno operated at losses in 1932, a new distributor entered the market in January, 1933.

[24] In Los Angeles County, where conditions relative to the distribution of grade-A raw milk seem to have been more favorable than in any other county in California, less than 40 per cent of all the milk distributed in 1931 was grade-A raw milk.

fore, as the volume of raw milk distributed is increased, a greater burden in disposing of surplus milk will be thrown on the producers of milk for pasteurizing purposes, who will probably always constitute the bulk of the dairymen supplying milk to Fresno.

If there is a persistent demand on the part of consumers in Fresno for grade-A raw milk and if this can be produced under sanitary conditions which will safeguard the health of the consuming public, it would be better from the point of view of all dairymen for grade-A raw milk to be distributed through the existing distributive channels, or for raw-milk producers to organize a new raw-milk distributing company.

If permanent improvement is to be introduced into the Fresno market-milk industry, it will be necessary for all groups to explore every possible means of restricting the number of new distributing units and even of decreasing the number of existing plants. Reduction of margins as a result of elimination of inefficient methods of delivery, the introduction of a universal store bottle and deposit requirement, the formation of a strong producers' bargaining organization, and an educational campaign among consumers promoted by the market-milk industry as a whole as to the possible results of any further increase in distributive facilities will have much influence in discouraging the entry of new competitors.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Consumption and Prices Paid by Consumers.—The volume of milk distributed by the four plants in Fresno has declined appreciably since 1930. Part of this decline can be ascribed to some loss of trade to distributors operating outside the city limits of Fresno; part may be due to a decline of transient fruit-picking and packing population during the fruit-picking season; part is undoubtedly due to some decline in per-capita consumption as a result of a decrease in purchasing power.

About 60 per cent of the milk distributed in Fresno is sold through retail grocery stores and only 15 per cent directly to the homes of consumers. The rest is sold to hotels and restaurants, public institutions, and bakeries, drug stores, etc. Prior to June, 1930, store prices to consumers and retail prices for milk were equal. Since June, 1930, store prices have been 2 cents below retail delivered prices. Taking these facts into consideration, prices paid by consumers have declined from 14 cents in 1929 to 10 cents (store price) in 1932, a decrease of 28.5 per cent, which compares favorably with the decline in retail prices of foodstuffs generally in San Francisco. Moreover, as the average milk fat content

of market milk increased from 3.7 per cent in 1929 to 4 per cent in 1931 and 1932, consumers are receiving the benefit of a higher quality of milk.

It is nevertheless strongly recommended that producers and distributors exert every possible effort to effect still further reductions in prices paid by consumers. In the absence of an appreciable improvement in business conditions, a reduction in prices paid by consumers would assist materially in increasing per-capita consumption or in retarding a further decline. Concerted industry advertising would also appear to be of value. It is particularly important that both producers and distributors develop some means of bringing before the consuming public the problems and difficulties confronting the market-milk industry. Such educational and public-contact work would do much to prevent future adverse publicity.

Prices Paid to Dairymen.—Prior to 1929 dairymen producing market milk were paid 24 cents a gallon for milk testing 3.6 per cent milk fat and over. In March, 1929, the prices were increased to 28 cents a gallon for milk from herds free from tuberculosis. At the same time stricter sanitary requirements were introduced. Since the beginning of 1930 prices to dairymen have declined more or less steadily. The absolute decline in buying prices for market milk since 1929 has been greater than that for manufacturing milk, so much so that in 1932 the average yearly differential of market-milk prices over those of manufacturing milk was as low or lower than the differentials prevailing during the years 1926 to 1928, prior to the introduction of the strict sanitary requirements now prevailing. While the prices of some of the cost factors in market-milk production such as feed and labor have declined since 1928, it is probable that compliance with the stricter sanitary requirements has tended to increase the differences in unit costs of producing market milk and manufacturing milk since 1928. Market-milk dairymen were emphatic in stating that they could not continue for any length of time producing milk for the prices they were receiving during the last few months of 1932. It is possible that if these prices continue much longer the milk supply of Fresno may be jeopardized.

The data collected during the course of this study indicate that some increase in buying prices to dairymen would be justified. It is recommended that every effort be made to bring this about. An increase in buying prices to dairymen by increasing prices paid by consumers would not be warranted under existing conditions, for this would tend to still further decrease consumption. Any increase in buying prices would thus have to be effected through economies in the handling and distribution

of market milk. Some reduction of hauling rates and a more efficient system of hauling would seem to offer some prospects of savings which could be used to increase the net returns to market-milk dairymen.

Distribution: Margins and Costs.—While the volume of milk distributed in Fresno has declined appreciably since 1929, the number of distributors has increased. In 1929 two distributors handled more milk than the four distributors together in 1932. Both of the distributors operating in 1929 handled considerably less milk in 1932 than they did in 1929. All four distributors in 1932 were operating well below capacity.

When consideration is given to the fact that the proportion of milk sold wholesale increased from about 50 per cent in 1929 to about 85 per cent in 1932 and that the milk-fat content of market milk also was increased from 3.7 per cent in 1929 to 4 per cent in 1932, distributors' margins during the last half of 1932 were little if any greater than in the years prior to 1929. Owing to the differences in the conditions of market-milk distribution in various cities, it is extremely difficult to ascertain whether distribution costs and margins are higher in Fresno than in other cities. It is possible to state, however, that a more efficient system of distribution in Fresno would result in a substantial reduction in both margins and costs.

Although distributors' margins during the years prior to 1929 were probably adequate to meet unit operating expenses and to provide for an attractive return on invested capital, margins in 1930, 1931, and 1932 proved inadequate to meet even the operating expenses of the four distributors. Two distributors made a small profit in 1930 and 1931 after provision had been made for depreciation. Two distributors made a loss in both years. In 1932 all four distributors showed a net operating loss. The losses of some of the distributors during some of the years were in excess of the amounts set aside for depreciation. In these cases distributors incurred actual cash losses.

The combined assets of the four distributors exceeded one and a quarter million dollars. Included in the assets of three of the distributors were amounts for goodwill. None of the four distributors were able to pay dividends on capital invested during the past three years out of earnings made on the operations of their plants in Fresno.

From an industry viewpoint the system of market-milk distribution in Fresno is uneconomical. This has resulted in the failure of individual firms to make any profits on their operations during the past three years in spite of the fact that margins have not declined to any extent and that the prices of many of the cost factors of production have declined.

In the first place the capacity of each of the four pasteurizing plants is far in excess of the volume of milk and other products being handled by them individually. As a result unit costs of processing and delivery of each plant are higher than they would be if each plant were operating more nearly to capacity. It is probable that all the milk sold in Fresno could be handled adequately by one or at most two plants.

In the second place competition between individual distributors to build up or maintain volume of business has resulted in the introduction of practices in the delivery of milk which apparently have not resulted in benefit to a single distributor and which at the same time have tended to increase unit costs of selling and delivery. The lowering of the store price to consumers to 2 cents a quart below retail delivered prices in 1930 was one of the prime factors responsible for the large increase in consumer purchasing through stores. As a result of efforts by distributors to gain store trade over half of the stores were being served by two or more distributors in 1932 and stores and restaurants were receiving several deliveries each day. In many instances the quantities of milk delivered each day and with each delivery were extremely small. Nearly all distributors have at one time or another granted special discounts to stores over and above the agreed-upon schedules of wholesale prices.

It would appear that some reduction of store margins and the services given stores by distributors would help to place the market-milk industry of Fresno on a more rational and economical basis. Relative store margins on market milk have increased since 1929 and 1930 notwithstanding the fact that nearly all stores handled a much greater volume of milk in 1932 than they did in 1929. Relative store margins on milk, moreover, are wider than on many other commodities; in fact several grocery store operators claim that they rely upon the wide margins on milk to operate on narrow margins on some other goods. For a point of view of the comparative service rendered by producers, distributors, and stores, the store margin is out of line with the prices and margins of the other two groups.

All responsibility for the uneconomic methods of handling market milk in Fresno cannot with any fairness be placed on any one group or individual. Similar conditions prevail in a large number of milk markets throughout the United States and in fact in most other industries as well. It would seem, however, that distributors in Fresno as a group can be criticized for their tardiness in eliminating undesirable trade practices, which all distributors were aware were operating to the disadvantage of the industry. Certain definite steps can be taken to improve

conditions in the market-milk industry of Fresno. The attainment of such improvements will require the combined efforts and cooperation of all groups in the Fresno market-milk industry, producers, consumers, distributors, retail store operators, and public health authorities.

Recommendations for Improvements.—It is not considered that the distribution of raw milk by individual dairymen would prove either of immediate or ultimate benefit to the industry. Such a step would tend to increase still further plant and delivery facilities without increasing to any appreciable extent the volume of milk being sold. Competition between the various distributors would be intensified and more undesirable and uneconomic trade practices are likely to result. If raw milk is to be distributed, it would be preferable, from an industry standpoint, for it to be handled through the existing distributive channels, provided, of course, that distributors would not exact too wide a margin for handling raw milk, or through a company to be formed by the raw-milk producers themselves.

On the contrary, a decrease in the number of plants operating in Fresno would be more likely to be of immediate and ultimate benefit to the industry. It is strongly recommended that all groups interested in the Fresno market-milk industry explore every possible means for effecting a decrease in the number of distributing plants and in discouraging the entrance of new distributors. The most effective means under existing conditions for discouraging the entrance of new competitors would be for distributors to effect a substantial reduction in their unit costs and margins. An amalgamation of one or more of the existing plants would be a step in the right direction. The greater volume handled by the remaining plants would enable them to operate on a lower unit-cost basis.

It is suggested, furthermore, that costs of distribution can be reduced:

1. By requiring that the established wholesale price of milk to stores and restaurants apply only to minimum purchasers of a case of milk at a time, purchases of less than a case at a time to be on a somewhat higher basis.

2. By restricting deliveries at the lowest rates per case by any one distributor to twice daily during the summer months and to once daily during winter months, a higher price to be charged on special deliveries.

3. By providing that the established lower prices apply only in the case of stores and restaurants purchasing milk regularly from a distributor. This would prevent stores and restaurants from ordering milk

occasionally from another than their regular supplier in order to obtain the benefits of a lower price.

4. By trading business, whenever it can be equitably arranged to the satisfaction of all parties. Under such a plan store X, which purchases milk from distributors A and B, will receive all its milk from A. Store C, which also receives its milk from A and B, would receive milk only from B. Such an arrangement would be facilitated if there were fewer distributors.

5. By the elimination of all special discounts of whatever nature.

6. By attempts to get retail store operators to handle market milk on a somewhat lower margin.

7. By introducing a universal store bottle which only the present distributors would be allowed to use and by requiring consumers to pay a deposit on all bottles purchased from stores.

Another means of discouraging the entrance of new distributors would be the establishment of a milk trade board consisting of representation of distributors, dairymen, retail stores, restaurants, and the general public. The functions of this board would be to investigate all matters of dispute between the various groups interested in the Fresno market-milk industry, to collect and analyze data relative to the economics of milk-marketing and suggest means for the more economical handling of milk, to assist dairymen and distributors in determining from time to time buying prices and resale prices of market milk, and disseminate such information to the consuming public as will result in a better general understanding of the problems of milk-marketing.

It is suggested, furthermore, that the dairymen supplying market milk to Fresno form a collective bargaining association whose functions it will be to represent all members in negotiations with distributors, the milk board, and the consuming public, to establish from time to time and in collaboration with distributors and the milk trade board buying and resale prices for market milk, to establish basic quotas for individual members, to arrange for the best possible disposal of all milk produced by members in excess of requirements of distributors, and to arrange for methods and rates of hauling milk from members' farms to city plants. It would not be the purpose of such an association to restrict its membership to only those dairymen who are at present shipping milk to Fresno. Membership would be open to all dairymen who can comply with the necessary sanitary requirements and who are prepared to produce market milk for the established buying prices. Under such a plan dis-

tributors would still be allowed to select the dairymen from whom they would receive milk. The milk of one dairyman would be transferred from one distributor to another only with the consent of both distributors and the association.

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Finally the author wishes to express his appreciation to the many market-milk dairymen and to several retail-grocery-store operators in Fresno for their valuable assistance in supplying information about their respective operations.

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The Emergence of Pear Thrips in the Healdsburg Area of California in 1932

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Credit for the successful operation of the thrips traps is largely due to H. A. Weinland, Farm Advisor, Sonoma County, and numerous growers who coöperated with the University in this test. G. E. Stanley, manual training teacher in the Healdsburg High School, and his students constructed the traps.

THE EMERGENCE OF PEAR THRIPS IN THE HEALDSBURG AREA OF CALIFORNIA IN 1932[1]

LESLIE M. SMITH[2]

Unsatisfactory control of pear thrips, *Taeniothrips inconsequens* (Uzel), has frequently been reported within the last few years by the prune growers in the Healdsburg district of Sonoma County, California. Many growers were of the opinion that the thrips emerged from the soil for a much longer period in this area than is usually the case in other areas. It was suggested that the emergence from the soil in the Santa Clara Valley, where sprays and dusts have proved effective, might be much shorter, so that one or two applications yielded an effective control. In order to gather definite information on the emergence of thrips in the Healdsburg area, forty-five traps were distributed through the district, and the data given in the following pages were gathered.

METHOD

Each trap was shaped like a four-sided pyramid (figs. 1 and 2), with the base 3 feet square and the apex 2 feet in height. The base was constructed of 1×2 inch redwood. From each corner of the base a piece of 1×1 inch redwood extended at an angle of about 45° to a small block $\frac{3}{4} \times 3 \times 3$ inches at the top. In the center of the top of the block a hole was bored half way through of such size as to admit a small vial. This hole was continued by a smaller hole which opened on the lower side of the block (fig. 1*C*). A vial could be inserted in the hole in the top of the block, and the rim of the smaller hole formed a shoulder on which the mouth of the inverted vial rested when installed.

The frame was covered with a cheap but close-mesh muslin. The cloth was applied to the inside of the frame in order to reduce recesses which would impede the progress of the thrips or serve as hiding places for them. The cloth was tacked to the frame, the edges were then covered with half-round screen molding, and three coats of Tree-White were applied to the inside (fig. 1*B*). White was selected as the most desirable

[1] Received for publication October 11, 1932.

[2] Junior Entomologist in the Experiment Station.

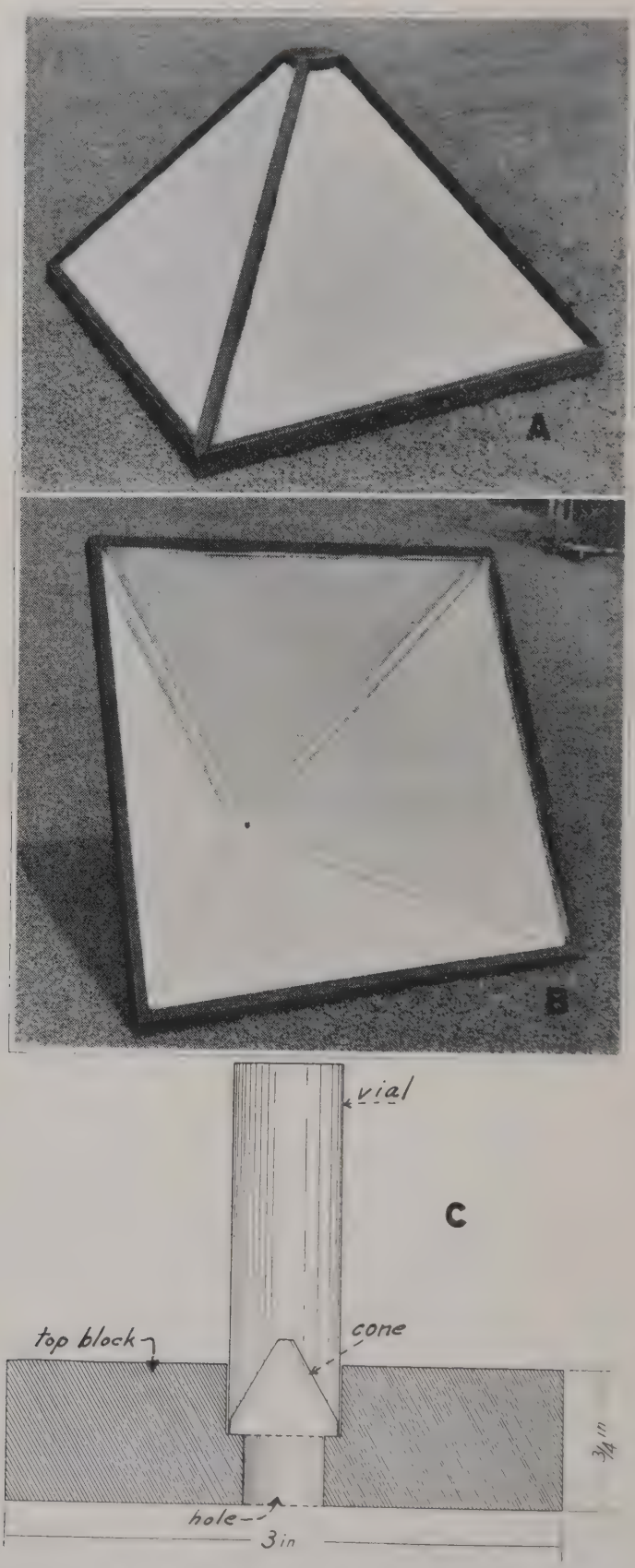


Fig. 1.—*A*, Exterior of trap. The hole in the top is for the insertion of the vial. *B*, Interior of trap. *C*, Section of vial, cone, and block at the top of the pyramid, showing arrangement and method of insertion.

color, since it would contrast with any adult, or "black" thrips which failed to pass from the pyramid into the vial, and by inverting the trap and counting the thrips on the inside the efficiency of the trap could be determined.

Although three successive coats of paint were applied to the inside of the traps, there still remained minute openings through the cloth, which in some cases were large enough to permit a thrips to pass through. As a check on the efficiency of the cloth traps, a number of traps were covered on the outside with a medium-weight roofing paper which was strapped along the edges by screen molding.



Fig. 2.—Traps in position in the field. Left, cloth; right, paper-covered trap.

The vials inserted in the tops of the cones were prepared to function as traps, similar to the common fly trap. A small truncate cone was glued in the mouth of each vial. In order not to impede the passage of light, necessary to attract the thrips to the top of the trap, the cone inside of the vial was constructed of transparent paper (Cellophane) and held in place by water-proof cement.

The traps were placed in the hands of the growers, with mimeographed directions describing the procedure to be followed and with materials to enable them to carry out the instructions. Growers were requested (1) to remove the vial from the top of the trap every second day, at the same hour, preferably in the morning, and replace with an empty vial; (2) to place a cotton plug in the end of the vial and pour on it a few drops of ether to kill the thrips; (3) to mark the vial with the trap number and date removed; (4) to move the trap to a new location in the same vicinity at the time of changing the vial, that is, every second day.

If the trap had stood on bare soil (that is, on soil from which the covercrop had been cut immediately before the trap was placed) they were requested to cut off the covercrop before placing the trap, otherwise to place it over the covercrop. The traps were moved every second day in order to avoid any change in soil temperature which might have resulted had the trap stood for a long period on the same square yard. Each time after the traps were moved, the lower edges of the frames were covered with soil to exclude light. At regular intervals the vials were collected, and the thrips removed and counted. The traps were distributed in the Healdsburg area in such a way as to cover as wide a variety of cultural practices as possible. An attempt was made to gather information on the relation of soil types, irrigation, and covercrops to thrips emergence.

In order to facilitate a comparison of results, each catch was divided equally between the days during which the vial was on the trap. With very few exceptions, the coöperators followed directions and changed the vials every second day. Traps were placed in representative orchards which were known to have been infested with thrips the preceding spring. Each trap was placed near the base of a tree, under as much of the top as possible (fig. 2), since it was presumed that the majority of thrips drop straight to the ground and transform and emerge without much lateral movement.

RESULTS

Efficiency of the Traps.—During the first few days of the emergence several questions bearing on the efficiency of the traps were settled. A comparison was made between the catches in cloth-covered traps and those in cages which, in addition to cloth, were covered with roofing

TABLE 1

EFFICIENCY OF TYPES OF TRAPS

Type of trap	Total thrips caught			
	First set	Second set	Third set	Average
Roofing paper	37	1,373	1,623	1,011
Cloth	190	571	2,165	975

paper. In several cases these two types of traps were placed within a few feet of each other and kept in this relation throughout the period of this test. The total catches of three such pairs of traps were as indicated in table 1.

From these counts it may be seen that the traps covered with roofing paper in addition to cloth were no more efficient than traps which were covered with cloth alone. The counts from these traps are included among those given in table 2. During the course of the experiment several factors appeared which indicated the superiority of the cloth alone. It was found that the temperature and humidity rose much higher in the paper-covered traps. Water condensed on the cloth and in the vial and interfered with the counting of the thrips. The paper-covered cages were more expensive to construct, heavier to handle, and more apt to break or puncture.

On numerous occasions when the vial at the top of the trap was found to contain a considerable catch, the trap was inverted and examined on the inside for thrips. Thrips were rarely found on the sides of the trap, and at most in very small numbers. From such observations it was concluded that after leaving the soil, or the covercrop, the thrips moved rapidly up the sides of the pyramid and entered the vial at the top.

Occasionally spiders caught in the traps constructed webs over the mouths of the vials and preyed upon the thrips and thus reduced the efficiency of the traps. Such spiders were removed as frequently as found. They rarely interfered with the operation of the trap for more than two days.

Total Emergence.—Twenty-one traps were placed in the field on February 18. On February 21, eleven of these had caught some thrips. The total accumulated catch on this day was 44. When this catch is divided as equally as possible between the three days during which the thrips were caught, and the odd thrips included with the catch on the latest day, the average catch per trap was as follows:

Date, 1932	Daily emergence, thrips per sq. yard	Cumulative total, thrips per sq. yard
February 19	0.5	0.5
February 20	0.7	1.2
February 21	1.0	2.2

While a few thrips may have emerged prior to February 19, the number must be very small and for the purposes of this paper, may be disregarded. The emergence on February 18 and preceding days is regarded as zero in the following computations.

The total number of thrips caught in the Healdsburg section (table 2) has been utilized in preparing the graphs of total emergence, figure 3*A* and *B*.

These data include emergences from irrigated and nonirrigated soils, light, medium, and heavy soil types, and various covercrop conditions. They may therefore be regarded as covering nearly all possible times of emergence, and present an approximation of the average emergence of all conditions. No records of soil temperatures were kept. The mean daily

TABLE 2

TOTAL EMERGENCE IN THE HEALDSBURG AREA

Date, 1932	Total thrips	Number of traps	Average thrips per square yard*		Date, 1932	Total thrips	Number of traps	Average thrips per square yard*	
			Daily	Cumulative total				Daily	Cumulative total
1	2	3	4	5	1	2	3	4	5
Feb. 19	10	21	0.3	0.3	Mar. 9	2,208	43	33.4	247.9
Feb. 20	15	21	0.5	0.8	Mar. 10	1,487	43	22.5	270.4
Feb. 21	20	21	0.7	1.5	Mar. 11	1,148	43	17.6	288.0
Feb. 22	22	21	0.7	2.2	Mar. 12	1,103	43	16.7	304.7
Feb. 23	128	21	4.0	6.2	Mar. 13	975	43	14.8	319.5
Feb. 24	249	35	4.6	10.8	Mar. 14	765	43	11.6	331.1
Feb. 25	487	39	8.1	18.9	Mar. 15	791	41	12.6	343.7
Feb. 26	501	41	7.9	26.8	Mar. 16	614	41	9.8	353.5
Feb. 27	586	42	9.1	35.9	Mar. 17	335	39	5.6	359.1
Feb. 28	1,079	41	17.1	53.0	Mar. 18	231	38	4.0	363.1
Feb. 29	1,318	41	20.9	73.9	Mar. 19	210	38	3.6	366.7
Mar. 1	902	40	14.7	88.6	Mar. 20	149	36	2.7	369.4
Mar. 2	1,293	40	21.0	109.6	Mar. 21	175	35	3.3	372.7
Mar. 3	1,505	39	18.6	128.2	Mar. 22	76	26	1.9	374.6
Mar. 4	952	38	16.3	144.5	Mar. 23	39	26	1.0	375.6
Mar. 5	637	42	9.9	154 4	Mar. 24	43	24	0 9	376 5
Mar. 6	915	41	14.5	168.9	Mar. 25	26	20	0.8	377.3
Mar. 7	1,018	41	16.1	185.0	Mar. 26	14	18	0 4	377 7
Mar. 8	1,949	43	29.5	214.5	Mar. 27	3	18	0.1	377.8

* Since some of the traps were on bare soil and some on the covercrop, the counts given in these two columns have been corrected by the formula:

$$\frac{\frac{10T}{N}+33\left(\frac{10.84T}{19.82N}\right)}{43}$$

in which 10 is the number of traps on bare soil, 33 is the number of traps on covercrop (see covercrop data, table 3), 43 is the total number of traps, T is the total thrips caught on any day (given in col. 2 of table 2), N is the number of traps on the same day (given in col. 3 of table 2), 10.84 is the average thrips per square yard emerging throughout the season from clean soil, and 19.82 is the number of thrips per square yard emerging throughout the season from soil under a covercrop. This formula is used to subtract those thrips which were on the covercrop at the time the traps were placed over it.

temperatures recorded at Santa Rosa are indicated by the dashed line in figure 3A. The arithmetical mean of the curve of emergence falls on the twentieth day of the test, or on March 9. The curve shown in figure 3A approximates the form of the normal curve except between the first and seventh of March. At this time a sharp depression in the numbers of thrips occurred. A study of the graph (fig. 3A) will show that this depression is correlated with a sharp depression of the mean tempera-

ture. During the first three days of lower temperatures the number of thrips emerging increased slowly; during the second three days of cold weather, the number emerging showed a marked decrease. It may be that the soil retained sufficient heat from the warm period of February 27–29 to account for the slight increase in emergence of thrips on March 2. The drop in mean temperature is therefore probably responsible for the departure in emergence from the expectancy indicated by the cumulative curve in figure 3*B*.

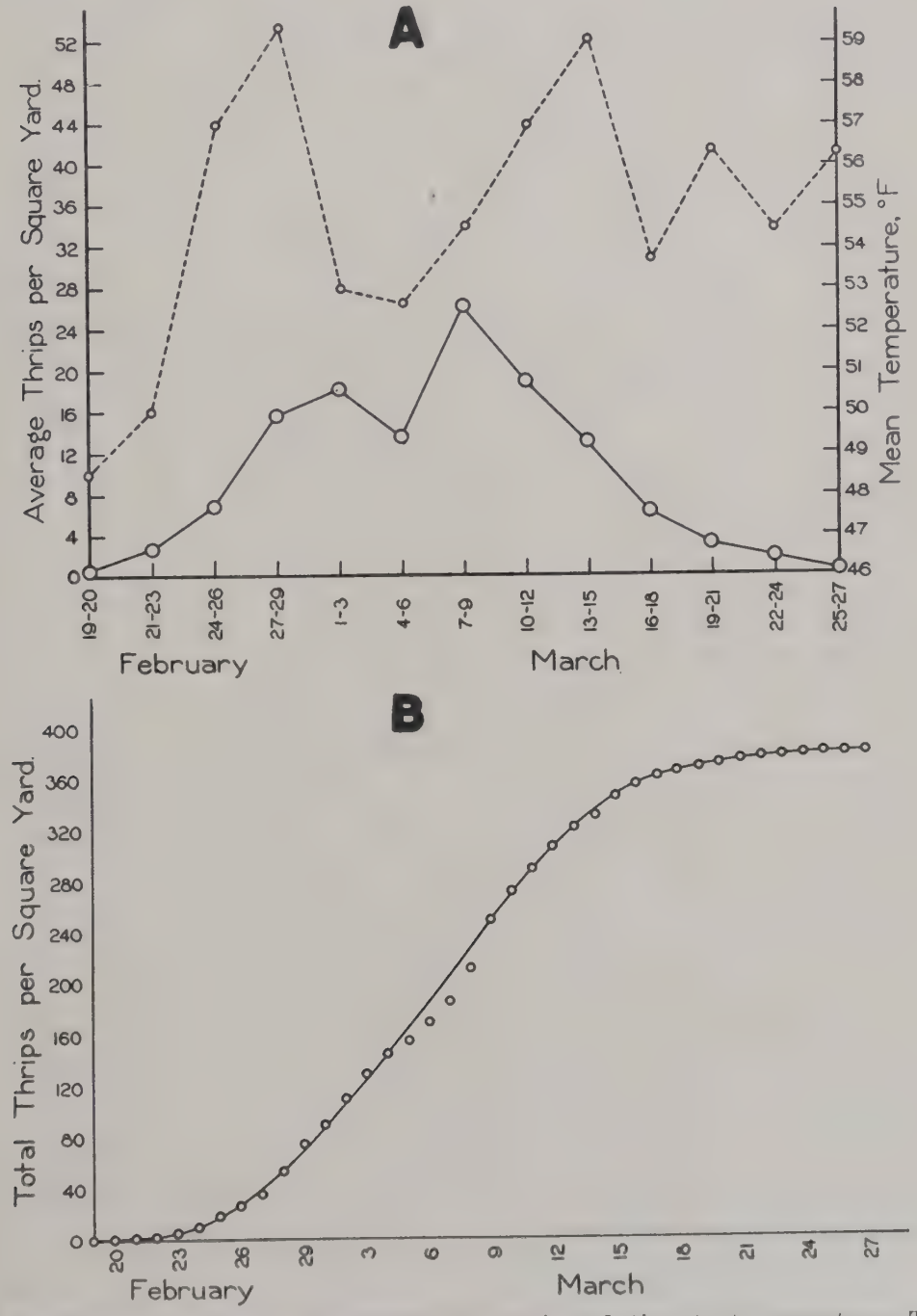


Fig. 3.—Emergence in the Healdsburg area in relation to temperature. The continuous line shows the emergence; the dashed line shows the mean temperature, based on three-day averages. (Data from table 2.) *B*, Accumulated total of average thrips per square yard. (Data from table 2.)

The total number of thrips emerging during the entire season averaged 377.8 per trap. This means that in orchards that were infested in the spring of 1931 every square yard that was overhung by branches gave egress to 378 thrips, on the average, this spring. The total period of emergence extended from February 19 until March 27, or a total of 38 days. The average daily emergence throughout the entire period from February 19 to March 27 was 9.9 thrips per square yard. The largest catch was 1,234 thrips in two days, or 617 thrips per square yard per day. Significant emergence, arbitrarily selected at 5 or more thrips per square yard, extended from February 23 to March 21, or a total of 28 days.

TABLE 3

COMPARISON OF SIGNIFICANT EMERGENCE PERIODS, HEALDSBURG AND SAN JOSE

Locality	Year	First emergence	Mode	Last emergence	Length of emergence period, days
San Jose	1909	Feb. 15	Mar. 3	Mar. 20	33
San Jose	1910	Feb. 9	Mar. 4	Mar. 17	36
San Jose	1911	Feb. 7	Mar. 12	Mar. 18	39
San Jose	1912	Feb. 6	Mar. 1	April 8	62
Healdsburg	1932	Feb. 23	Mar. 9	Mar. 21	28

The traps were moved every second day, as stated above, to a new location. In order to gather information regarding the total number of thrips in a selected square yard, and to obtain data for comparison with traps which were moved, three traps were left stationary throughout the emergence period on the spot where they were first placed. These traps caught a total of 311, 1,853, and 1.211, or an average of 10.0, 66.2, and 60.6 thrips per day, respectively. These three traps computed together show an average of 42.6 thrips per square yard per day, which is considerably in excess of the average emergence of all the traps, 9.9.

A comparison of the length of the emergence period in the Healdsburg area with that in the San Jose area is possible by contrasting the data herein presented with that obtained by Foster and Jones[3] in San Jose. In table 3 "first emergence" and "last emergence" refer to "significant emergence" as described above. The dates for San Jose, 1909–1912, are taken from Foster and Jones. Although the data from the two studies were obtained by somewhat different techniques, they are sufficiently comparable to indicate that the emergence period in the Healdsburg

[3] Foster, S. W., and P. R. Jones. The life history and habits of the pear thrips in California. U. S. Dept. Agr. Bul. 173:33, table IV. 1915.

area is not appreciably longer than in the San Jose area. Foster and Jones reared thrips from blocks of soil removed intact from infested orchards, and carried to their laboratory. In this paper, their data has been computed to thrips emerging per square yard of surface soil, and again significant emergence is recognized as 5 or more thrips emerging per square yard per day.

Covercrop.—Covercrops are generally believed to retard thrips emergence. This may be due to the fact that the covercrop shades the soil and maintains a lower temperature therein. No study of such a hypothesis was conducted during the test, but the relation of the total emergence to the mean temperature, already discussed, lends some support to it.

A second method by which the covercrop may delay the appearance of the thrips consists in retarding the flight of the emerged adults to the trees. In other words the covercrop may serve as a temporary abode for the adults. In order to obtain information on this question, ten of the forty-three traps reported upon in table 2 were placed on bare soil, that is, on undisturbed soil from which the covercrop was cut, just prior to placing the traps. These traps were moved every second day, and each time the covercrop was cut and removed before they were placed. In table 4 the daily average per trap computed from ten traps on clean soil is contrasted with the daily average per trap of thirty-three traps which were moved every second day and placed over fresh covercrop. As will be shown later, the emergence per square yard is greatly modified by soil types. Although the traps used in this covercrop test were placed on all types of soils, the soil factor does not render the results incomparable since of the bare-soil traps 70.0 per cent were placed on medium and heavy soils and of the covercrop traps 78.8 per cent were placed on soils of this type.

It was assumed that the average number of thrips emerging from freshly cleaned soil would approximate the number of thrips emerging from soil under a covercrop. Any additional thrips caught in traps on the covercrop were presumed to have emerged earlier and to have been resting on the covercrop when the trap was placed over it. The number thus present on the covercrop (column 4 in table 4) is computed as the difference between catches from the covercrop and from bare soil. The thrips on the covercrop probably enter the vial during the first twenty-four hours after the trap is placed because of their pronounced positive phototropism. During the second twenty-four hours the catch in covercrop traps is increased only by the further emergence from the soil. Since the traps were moved only once in two days, these two values are

averaged. If the traps had been moved every day, the number of thrips caught in the covercrop traps would probably have been nearly doubled.

These data show that the number of thrips per square yard remaining on the covercrop, after emerging, increased from none on February 19

TABLE 4

NUMBER OF THRIPS REMAINING ON COVERCROP

Date, 1932	Average thrips caught in traps on covercrop	Average thrips caught in traps on bare soil	Average thrips per square yard remaining on covercrop
1	2	3	4
Feb. 19	0.5	0.5	0.0
Feb. 20	0.7	0.5	0.2
Feb. 21	0.9	1.0	—0.1
Feb. 22	1.1	0.0	1.1
Feb. 23	6.1	4.3	1.8
Feb. 24	9.8	7.0	2.0
Feb. 25	12.9	12.3	0.6
Feb. 26	12.2	11.0	1.2
Feb. 27	14.9	11.1	3.8
Feb. 28	28.7	17.3	11.4
Feb. 29	34.3	17.9	16.4
Mar. 1	25.2	11.0	14.2
Mar. 2	39.6	6.4	33.2
Mar. 3	42.6	17.1	25.5
Mar. 4	24.2	15.2	9.0
Mar. 5	17.1	6.6	10.5
Mar. 6	26.3	8.1	18.2
Mar. 7	30.5	7.4	23.1
Mar. 8	49.7	31.0	18.7
Mar. 9	55.7	36.9	18.8
Mar. 10	36.6	31.7	4.9
Mar. 11	27.8	25.9	1.9
Mar. 12	31.6	14.8	16.8
Mar. 13	30.0	10.9	19.1
Mar. 14	21.3	6.3	15.0
Mar. 15	20.5	15.8	4.7
Mar. 16	15.8	11.9	3.9
Mar. 17	10.4	3.6	6.8
Mar. 18	7.3	2.2	5.1
Mar. 19	6.1	3.5	2.6
Mar. 20	3.8	4.5	—0.7
Mar. 21	5.4	3.1	2.3
Mar. 22	4.4	0.9	3.5
Total	654.0	357.7	297.1
Average	19.8	10.8	9.0

to 33.2 on March 2. From March 2 on, the number of thrips remaining on the covercrop decreased. From this standpoint alone, it would seem that the covercrop acted as an important retarding factor up to March 2, at which time its importance in this connection began to decrease, so

that the orchards could have been disked any time after March 2 without appreciably affecting the numbers of thrips on the trees.

Irrigation.—Fall irrigation has been both recommended and condemned in the literature as a means of destroying pear thrips in the soil.

TABLE 5

EFFECT OF IRRIGATION ON THRIPS EMERGENCE

Date, 1932	3 irrigations	2 irrigations	1 irrigation	No irrigations
	Average thrips per square yard			
Feb. 19	2.0	0.5	0.0	0.0
Feb. 20	3.0	0.5	0.0	1.0
Feb. 21	3.0	1.0	0.0	1.0
Feb. 22	1.0	0.5	0.0	0.0
Feb. 23	2.0	34.0	1.0	1.0
Feb. 24	22.3	27.7	2.0	0.7
Feb. 25	25.0	83.0	1.8	1.3
Feb. 26	25.3	83.0	1.8	1.3
Feb. 27	25.3	83.7	1.8	1.3
Feb. 28	16.7	136.0	0.3	1.7
Feb. 29	16.7	136.3	0.7	1.7
Mar. 1	0.0	2.0	0.0	49.7
Mar. 2	0.0	2.5	0.0	49.7
Mar. 3	14.7	31.5	3.0	14.0
Mar. 4	14.7	32.0	4.0	14.3
Mar. 5	1.0	4.3	4.5	17.0
Mar. 6	1.3	4.3	4.8	17.3
Mar. 7	2.0	5.0	5.3	17.7
Mar. 8	0.3	5.0	6.8	24.7
Mar. 9	0.3	5.0	7.3	25.0
Mar. 10	3.3	7.3	10.0	42.3
Mar. 11	4.0	7.7	10.3	43.3
Mar. 12	1.7	1.3	63.0	20.7
Mar. 13	1.7	2.0	63.5	21.3
Mar. 14	0.3	0.0	33.5	6.7
Mar. 15	5.0	0.0	33.8	7.0
Mar. 16	1.0	0.7	34.3	7.3
Mar. 17	0.0	0.3	11.5	0.3
Mar. 18	0.3	0.7	11.5	0.7
Mar. 19	1.0	0.0	12.0	1.0
Mar. 20	0.3	2.0	5.3	0.0
Mar. 21	0.7	2.0	5.3	0.0
Mar. 22	0.7	2.0	6.3	0.3
Total	196.6	703.8	345.4	391.3
Average	6.0	21.3	10.5	11.9

With the coöperation of Blaine McClish the following test of the efficiency of irrigation was conducted. Portions of his orchard were irrigated once, twice, and three times, while a fourth portion was not irrigated. The contour-check system of irrigation was used. At each irrigation, the land received approximately 6 acre-inches of water. The

three irrigations were applied on July 21, August 28, and September 29; the two irrigations were applied on August 28 and September 29; and the single irrigation was applied on September 29. Three emergence traps were placed in each irrigated area and three in the nonirrigated portion. The counts from these traps were included among those given

TABLE 6

EMERGENCE OF THRIPS FROM HEAVY AND LIGHT SOILS

Date, 1932	Heavy and medium soils, average thrips per square yard	Light soils, average thrips per square yard	Increase in average thrips per square yard surviving in heavy soils
Feb. 19	0.6	0.0	0.6
Feb. 20	0.9	0.0	0.9
Feb. 21	1.1	0.0	1.1
Feb. 22	1.3	0.0	1.3
Feb. 23	7.8	0.0	7.8
Feb. 24	11.3	1.4	9.9
Feb. 25	16.6	0.4	16.2
Feb. 26	14.6	0.8	13.8
Feb. 27	18.9	1.6	17.3
Feb. 28	34.7	1.8	32.9
Feb. 29	41.1	2.2	38.9
Mar. 1	28.6	2.7	25.9
Mar. 2	41.7	3.7	38.0
Mar. 3	47.9	5.0	42.9
Mar. 4	28.4	4.2	24.2
Mar. 5	18.0	3.8	14.2
Mar. 6	27.8	3.8	24.0
Mar. 7	31.7	4.3	27.4
Mar. 8	58.8	4.1	54.7
Mar. 9	67.1	3.3	63.8
Mar. 10	25.8	4.0	21.8
Mar. 11	33.8	7.3	26.5
Mar. 12	34.6	7.0	27.6
Mar. 13	32.1	5.4	26.7
Mar. 14	20.8	10.4	10.4
Mar. 15	21.6	11.8	9.8
Mar. 16	16.3	10.2	6.1
Mar. 17	9.6	7.0	2.6
Mar. 18	6.4	5.5	0.9
Mar. 19	5.4	5.9	—0.5
Mar. 20	5.1	1.3	3.8
Mar. 21	5.8	1.5	4.3
Mar. 22	3.2	0.7	2.5
Total	719.4	121.1	599.3
Average	21.8	3.7	18.2

in table 2. The data in table 5 were gathered. These data are so irregular that it is difficult to base an opinion on them. They indicate, however, that under some conditions as many as two irrigations applied late in August and September fail to reduce materially the number of thrips which emerge the following spring.

Several orchards were flooded in December, 1931, when, as a result of heavy rains, the Russian River overflowed its banks. Three traps were placed on situations that had been submerged from 1½ to 6 feet deep, and for periods of one to several days. The data from these traps are included in table 2. These traps caught a total of 277, 1,334, and 1,894 thrips, or an average of 40.3 thrips per square yard per day. This is considerably greater than the average daily emergence, 9.9.

The data gathered on emergence from irrigated and flooded land indicate that under certain conditions even large amounts of water are not inimical to thrips survival.

Soil Types.—The soils involved in this test were classified before the emergence into three groups: heavy, medium, and light. The data in table 6 are based on ten traps on light soils and thirty traps on heavy and medium soils. The data from these traps are included in table 2. These two latter types are treated as one, since no appreciable differences existed in numbers of thrips emerging from them. All of the traps were placed in orchards where thrips were known to have been injurious the preceding spring, so that the numbers of thrips which entered the various soil types were probably similar.

These data show a much greater emergence of thrips from heavy than from light soils. The emergence from heavy soils was more than twenty times as great as that from light soils on March 9 and averaged about six times as great throughout the period of emergence.

Control Measures to Reduce the Thrips Population the Following Spring.—Considerable importance is attached to the possibility of killing the larvae while still on the trees, in order to reduce the thrips population the following spring. During the spring of 1931 various growers applied sprays and dusts in an attempt to control adults and larvae. Many of the traps used in these emergence tests were placed in orchards which had been sprayed and dusted the preceding spring. The types of applications and emergence of thrips from them are given in table 7.

These data fail to show any correlation between spray practice and numbers of thrips emerging the following spring. However, it should be borne in mind that the amount of spraying which is done is generally in proportion to the amount of injury or numbers of thrips present, so that the orchards which received multiple applications may be regarded as having the heaviest infestations. The counts indicate that as many as three to six applications of sprays and dusts failed to reduce the thrips population to a negligible number.

TABLE 7

RESULTS OF SPRAYS AND DUSTS APPLIED THE PRECEDING YEAR

Control measures		Number of traps	Average daily emergence per square yard
Material	Number of applications		
Nicotine dust	1	1	60.6
Nicotine dust	1	1	1.5
Nicotine dust	1	1	11.1
Nicotine spray	1	1	15.8
Soap and nicotine	1	1	4.1
Nicotine dust	2	1	44.5
Nicotine dust	2	1	1.2
Nicotine dust	2	2	5.5
Nicotine spray	1	1	11.1
Nicotine dust	1		
Nicotine spray	1	1	66.2
Nicotine dust	1		
Nicotine spray	1	1	9.0
Nicotine dust	2		
Nicotine spray	1	2	3.7
Nicotine dust	2		
Nicotine dust	6	3	43.2
None	....	1	0.0
None	....	1	1.0
None	....	1	27.7
None	....	3	3.5
None	....	13	8.1

SUMMARY

A satisfactory type of trap suitable for gauging thrips emergence was devised.

The total emergence occurred over a period of 38 days, from February 19 until March 27. The peak of the emergence (empirical mode) and the arithmetical mean occurred on March 9. The normal curve of emergence was distorted by the influence of temperature.

A covercrop was found to delay the movement of thrips to the trees, after they had emerged from the soil. The number of thrips remaining on the covercrop reached a maximum of 33.2 thrips per square yard on March 2.

Irrigation and natural flooding did not appreciably reduce the emergence.

Heavy soils showed a much greater emergence than light soils. The average daily emergence per square yard from heavy soils was 21.8, from light soils 3.7.

Control measures applied in the spring of 1931 did not produce demonstrable results in 1932.

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THE OBJECTIVES AND ACTIVITIES OF THE CALIFORNIA FARM BUREAU

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THE OBJECTIVES AND ACTIVITIES OF THE CALIFORNIA FARM BUREAU[1,2]

E. D. TETREAU[3,4]

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The farm bureau was developed in California to provide a channel through which the Agricultural Extension Service could more readily reach farm communities in its educational work. The first county farm bureau was organized in Humboldt County in 1914. By 1919 there were no less than 35 county farm bureaus; in 1932 there were 41. The combined membership of all the county farm bureaus amounted to 24,168 in the fiscal year 1919–20 and 23,796 in 1931–32. The California Farm Bureau Federation was organized in 1919 to make possible unified action by the county farm bureaus on state-wide and nation-wide problems affecting agriculture.

The structure of the farm bureau in California was planned to afford farmers an effective vehicle for self-protection, self-representation, and self-development. The farm family and rural community were of more importance in the determination of the structure than any one farm commodity or economic function. The main objectives of the farm bureau have been the development of farm people and the promotion of their welfare. These objectives have been supplemented by contributing objectives which have been within the reach of practical achievement.

The Federation operates several service departments and a number of commodity departments, which are integrated with and work with similar departments in many of the county farm bureaus. These departments have functioned successfully and have contributed to the broad objectives of the farm bureau. Both the Federation and many county farm bureaus have also engaged in various commercial activities. These activities have included the operation of marketing and purchasing associations, the negotiation of trade discounts and rebates on behalf of

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[4] Special acknowledgment is due to J. M. Tinley for his services in editing and preparing the manuscript for publication after the author had returned to Ohio.

members with local dealers, the negotiation of group insurance rates with insurance companies, and the rendering of assistance to members in the formation and improvement of cooperative associations.

Commercial activities have been undertaken partly as a means of rendering a wider range of service to members, partly as a means of maintaining membership, and in a few cases as a means of obtaining additional membership. The experience of the farm bureau in California in some of its commercial undertakings has not proved satisfactory. In many of the counties the failure of marketing or purchasing associations or departments resulted in severe financial loss to members. The county farm bureau was in many instances held to blame for the failure of these associations. The outcome was a marked decline in membership, which in a few counties eventually led to the discontinuance of the county farm bureau. In a number of counties the operation of purchasing associations was successful, but some of these associations after a while severed their connection with the farm bureau. As many of the members were mainly interested in the operations of the purchasing association they also withdrew from the county farm bureau. The California Farm Bureau Federation itself organized a subsidiary marketing association which operated for a number of years and also acted for some time as state agent of a mutual automobile insurance company. Its experience in commercial operations proved no more satisfactory than that of county farm bureaus.

There seems to be an inherent danger in the engaging of a general-purpose farmers' organization in collective selling and purchasing operations; namely, that officials may devote too much attention to these activities and neglect other and more fundamental activities. All general-purpose farmers' organizations are continually faced with the problem of providing for and carrying on vigorously a wide range of activities demanded by members and at the same time of devoting to each activity no more time than is justified by the contribution of that activity to the wider and more fundamental objectives of the organization. The greatest stimulus to provide a wide and well-balanced range of activities is present when the organization is financially dependent upon dues periodically subscribed by members. If the organization has some outside source of revenue in place of or in addition to membership dues, the urge to obtain the support of members through useful service is lessened.

If commercial activities are to be undertaken by the California farm bureau it would appear to be justified in undertaking only such activities as will not require a disproportionate amount of time by officials, will not involve the county farm bureaus or the Federation in financial

obligations, and will result in direct savings to members of the farm bureau as such. With certain qualifications the negotiation of trade discounts and rebates and specially favorable insurance rates on behalf of members would come in this category. Assistance to cooperative associations and to members in the formation and strengthening of cooperative associations and general educational work in connection with the marketing of farm products and the purchase of farm supplies are activities which are in harmony with the broader objectives of the organization. It appears especially desirable that the farm bureau should not undertake any commercial activities which may bring it into competition with the cooperative associations which are in operation in nearly every important agricultural county in California.

It is recommended that the farm bureau confine its commercial activities as far as practicable within the limits outlined above and at the same time use every effort to work out with existing cooperative organizations improvements in the methods of purchasing of farm supplies and of marketing farm products.

REASON AND PURPOSE OF THE STUDY AND SOURCES OF DATA

Ever since it was organized the California Farm Bureau Federation has been interested in the cooperative marketing of farm products and the collective purchasing of farm supplies. During the past two years interest in the possibilities of the farm bureau's undertaking the collective purchase of farm supplies has been revived by the activities in this field of several general-purpose farmers' organizations in eastern states. It was deemed advisable, however, before the California farm bureau took any definite action in the matter, that a comprehensive survey be made of the problems, difficulties, and benefits of collective purchasing and especially of the relation of commercial activities[5] to the other functions and objectives of the farm bureau. As a result the Board of Directors of the California Farm Bureau Federation requested the Giannini Foundation of Agricultural Economics in the summer of 1931 to make a study of collective purchasing. In November of that year two related projects were begun. The one had to do with the objectives and activities of the farm bureau, with special attention to its commercial

[5] The term "commercial activity" refers principally to the operation of associations by the various farm bureaus, either directly or through the use of subsidiary forms of organization, for the purpose of marketing farm products or purchasing farm supplies or both marketing and purchasing. It also applies to such activities as selling automobile insurance, arranging special terms for workmen's compensation insurance, securing trade discounts with local merchants and dealers for farm-bureau members, and operating marketing and purchasing departments.

activities; the other was to deal more strictly with the economic phases of cooperative purchasing. This bulletin presents the information collected in the first-named investigation.

The purpose of this investigation was to define the objectives of the farm bureau, to describe its activities, and to show the relation between the various activities of the farm bureau and the attainment of its objectives. Considerable space is herein devoted to a description of the commercial activities of the farm bureau. Appraisals are made of the contributions of these commercial activities to the attainment of the farm bureau's objectives.

The records of the California Farm Bureau Federation, particularly the minutes of the Executive Committee meetings, of activity conferences, and of annual meetings, were important sources as to both the objectives and the activities of the farm bureau. The files of the Extension Service of the College of Agriculture furnished statistical and historical data concerning membership in the county farm bureaus, attendance at local meetings, and some of the earlier marketing and purchasing associations of the county farm bureaus. A questionnaire directed to the various county farm bureaus of the state was employed to gather information about marketing and purchasing associations and trade-discount arrangements with local merchants and dealers. Information was supplied by farm advisors and farm-bureau secretaries and officers. The personnel of the California Farm Bureau Federation, of the Extension Service of the College of Agriculture, and of the Giannini Foundation of Agricultural Economics, offered valuable (unrecorded) sources of information. The writer, assisted by several graduate students in agricultural economics[6] visited and interviewed over 400 farmers in different parts of the state. During these interviews answers were obtained to a number of specific questions set forth in the form of a questionnaire. The information so obtained furnished a basis for a comparison of members and nonmembers of general farmers' organizations such as the farm bureau, the grange (Patrons of Husbandry), and the Farmers' Union in regard to size of farm enterprise, methods of marketing products, methods of purchasing supplies, experience in cooperative associations, number of organizational affiliations, and opinions regarding the functions of the Farm Bureau.

[6] The field assistants were: Ogden King, G. P. Barber, S. G. Sparks, and B. F. Lucas. Professor A. E. Anderson of Brookings, South Dakota, on leave of absence to attend the University of California, spent three days in the field.

AGRICULTURAL CALIFORNIA

The state of California contains nearly 100,000,000 acres, of which some 30,400,000 acres, or 30.4 per cent, are in farms. Crop land in 1929 constituted about one-third of the acreage in farms. The most important farming regions[7] are those of the great interior valley watered by the Sacramento and San Joaquin rivers, the coast valleys, and the valleys and plains south of the Tehachapi Mountains. The mountain regions are given over almost entirely to livestock production. (See fig. 1.)

The wide range in soils and climatic conditions makes possible the production of a wide range of agricultural products. It is estimated that about 180 different marketable products are grown in California. Some of the most important of these are oranges, lemons, avocados, grapes, apricots, pears, peaches, melons, dairy products, beef, sheep, poultry, alfalfa, grain, and a wide variety of vegetables. Much of the production of agricultural commodities is specialized, farmers concentrating on the production of only one product or one or more complementary products, such as alfalfa and dairy products.

Only about one-tenth of the population of California is on farms.[8] There is a wide range in the proportion of farm to total population in different sections of the state. In the great interior valleys from 25 to 35 per cent of the population is on farms, whereas in the San Francisco Bay region (usually named the Bay region) and the south coast region the proportions are 5 and 3 per cent respectively. During the years 1900 to 1930 the farm population of California more than doubled. During the same period, however, the total population of the state nearly quadrupled. While over 80 per cent of the farm population of California is white, nearly 16 per cent belongs to other than the white and Negro races. Orientals constitute a large part of this classification. California's farm population contains a larger proportion of Orientals than any other state in the Union. Negroes form a very small proportion of the total population.

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[7] For convenience in the study of individual farm families, four of the most important agricultural regions in California are here designated as the south coast, the San Joaquin Valley, the Sacramento Valley, and the Bay region. The south coast includes Los Angeles, Orange, San Diego, and Ventura counties; the San Joaquin Valley includes Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties; the Sacramento Valley includes Butte, Colusa, Glenn, Sacramento, Sutter, Tehama, Yolo, and Yuba counties; and the Bay region includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties (fig. 1).

[8] United States Department of Commerce Bureau of the Census. Fifteenth Census of the United States, 1930. Population. Vol. 3(1):251–258. 1932.

A large number of cooperative marketing associations have been organized to handle the products of their members in local and distant markets. Many of these associations handle millions of dollars worth of products annually. Some of them in turn have set up purchasing departments or subsidiaries which handle packing materials, spray materials, fertilizers, poultry and dairy feeds, and other supplies. In 1930 there were about 550 of these farmers' business associations in California, with a total of some 100,000 members. The number of associations and the membership constituted less than 5 per cent respectively of the totals for the United States. The volume of business done by California associations, however, amounted to about 10 per cent of the volume of business done by all cooperative associations in the United States.

THE DEVELOPMENT OF THE CALIFORNIA FARM BUREAU

The Farm Bureau and the Agricultural Extension Service.—About 1913 an agricultural extension division was created in the College of Agriculture, University of California at Berkeley. The functions of this division were to be and still are of a purely educational nature, to extend to farmers the knowledge which agricultural colleges, experiment stations, and the United States Department of Agriculture have gained through the research work of numerous investigators in different fields. It was felt that the work of the Agricultural Extension Service among farmers would be facilitated if it operated with and through local farmers' organizations in each county. As there were no suitable organizations in existence at the time, it was decided to promote the formation of county farm bureaus as had been done in several other states. It was the definite intention of the sponsors of the farm-bureau movement that the functions of the county organizations would be purely educational—the channels through which county farm advisors[9] and the extension specialists would work in reaching individual farm operators and their families. The appointment of a farm advisor to any county was made contingent upon the formation of a county farm bureau with at least 20 per cent of the farmers in that county as members.

Thus while local county farm bureaus and the Agricultural Extension Service were since the beginning separate and distinct organizations, there was a very close working arrangement between them. After several years, however, the county farm bureaus began to extend their functions beyond the field of education. It was felt that they could serve their

[9] The county agricultural extension agent or "county agent" is known in California as the "farm advisor." This term instead of "county agent" is used throughout in this bulletin.

members to greater advantage by interesting themselves and representing their members in such matters as cooperative marketing of farm products, purchasing of farm supplies, legislative work affecting agriculture, irrigation and drainage projects, and power rates. Such work was undertaken by the county farm bureaus as separate organizations. The Agricultural Extension Service has never associated itself with the farm-bureau organizations in any activities not of a purely educational nature. The original relation between the farm bureau and the Agricultural Extension Service in the field of education has, however, continued uninterruptedly up to the present time.

In the fiscal year 1931–32 there were farm advisors in every county in California which had a county farm bureau with the exception of Nevada and Placer counties. Humboldt County, in which the county farm bureau was discontinued in 1929, still had a farm advisor whose services were also made available by special arrangement to farmers in Del Norte County. In many counties there are in addition to the farm advisor one or more assistant county farm advisors and a home demonstration agent. All these officers are the county representatives of the Agricultural Extension Service. They are public officials employed and paid jointly by the University of California and the United States Department of Agriculture. The county farm advisors and home-demonstration agents cooperate very closely with the officials of the county farm bureau in planning and carrying out their educational work among the farmers of the county.[10]

Development of County Farm Bureaus.—The first county farm bureau was organized in Humboldt County in the summer of 1913.[11] There was a steady increase in numbers up to 1916–17, when there were 17 county farm bureaus (table 1). The next year the number almost doubled. Two more were formed in 1918–19. It was estimated that in 1919 farm bureaus had been formed and farm advisors appointed in counties embracing 85 per cent of the farmers in California.[12] Since 1918–19 only 9 more county farm bureaus have been formed. Three county farm bureaus (Inyo, Glenn, and Humboldt) have been discontinued. Shasta County farm bureau, which was discontinued in 1925–26, was started again in 1929–30. In 1931–32 there were 41 counties with farm bureaus,

[10] The farm advisors in each county are required to furnish statements annually to the Director of the Agricultural Extension Service on the activities of their offices during the previous year. These statements furnished much of the information used in preparing this manuscript.

[11] This was the first county farm bureau west of the Rocky Mountains as well as the first in California.

[12] Crocheron, B. H. The function of the farm bureau. California Agr. Exp. Sta. Cir. 209:3. 1919.

17 counties[13] without farm bureaus (fig. 1). Most of the latter were situated either in mountainous or desert country or in counties which are largely urban and suburban (San Francisco, San Mateo), in either event counties with very small farm populations.

TABLE 1

NUMBER OF COUNTY FARM BUREAUS IN CALIFORNIA, 1913–14 TO 1931–32

Fiscal year	Number of county farm bureaus	County farm bureaus organized during year		County farm bureaus discontinued during year	
		Number	Name	Number	Name
1913–14	4	4	Humboldt, Yolo, San Joaquin, San Diego	....	.....
1914–15	9	5	Napa, Solano, Glenn, Alameda, Madera	....	.....
1915–16	11	2	Stanislaus, Placer	....	.....
1916–17	16	5	Sacramento, Nevada, Merced, Riverside, Imperial	....	.....
1917–18	31	15	Shasta, El Dorado, Sonoma, Sutter, Yuba, Mendocino, Contra Costa, Santa Cruz, Monterey, Fresno, Tulare, Kings, Los Angeles, Orange, San Bernardino	....	.....
1918–19	32	1	Tehama	....	.....
1919–20	32	....	.....	....	.....
1920–21	34	2	Ventura, Santa Barbara	....	.....
1921–22	39	5	Kern, San Luis Obispo, Butte, Marin, San Benito	....	.....
1922–23	41	2	Lassen, Inyo	....	.....
1923–24	42	1	Colusa	....	.....
1924–25	43	1	Lake	....	.....
1925–26	42	....	.....	1	Shasta
1926–27	42	....	.....	....	.....
1927–28	41	....	.....	1	Inyo
1928–29	40	....	.....	1	Humboldt
1929–30	42	2	Shasta, Modoc	....	.....
1930–31	41	....	.....	1	Glenn
1931–32	41	....	.....	....	.....

Sources of data:

Records of the Agricultural Extension Division, College of Agriculture, University of California, Berkeley; and the California Farm Bureau Federation.

California Farm Bureau Federation.—As the county farm bureaus grew in number and the scope of their activities increased, it became apparent that a number of problems concerning the well-being of farmers were state-wide and even nation-wide in scope, and that effective and concerted action on such matters could not be taken while each county farm bureau operated independently of the others. The Agricultural Extension Service was a state-wide organization connected somewhat loosely with the extension services of other states through the United States Department of Agriculture.

[13] Del Norte, Humboldt, Siskiyou, Trinity, Plumas, Glenn, Sierra, Amador, Alpine, Calaveras, Tuolumne, Mariposa, Mono, Inyo, San Francisco, San Mateo, and Santa Clara.

In 1919 delegates from 28 county farm bureaus met in Berkeley, in response to a call from the Director of Agricultural Extension, to form a state-wide farm-bureau organization, which adopted the name of the California Farm Bureau Federation. The views of the delegates as to the need for and interests of the California Farm Bureau Federation were summed up in a series of fourteen points which emphasized the need for united action on certain matters by county farm bureaus, for a federation of state farm bureaus, increased production, cooperative marketing, cooperation with other farmers' organizations, education, and the development of rural community life. Ten committees were appointed at the meeting representing livestock, grain, citrus and deciduous-fruit growers, education, legislation, cooperation, community improvement, marketing, irrigation, and drainage.[14]

Farm-Bureau Membership 1918–1931.—The most complete record on the membership of county farm bureaus is that available in the files of the office of the Director of Agricultural Extension, College of Agriculture, Berkeley (table 2, col. 1). These records, compiled annually by the county farm advisors, show a steady increase in membership of county farm bureaus up to the fiscal year 1922–23, when the combined membership reached 27,398. The following year there was a decline in membership of over 4,500. Since 1923–24 membership has fluctuated between 22,800 and 25,000, although during the past two years (1930–31 and 1931–32) there has been a tendency for membership to decline. Since 1919 when the California Farm Bureau Federation was organized, that body has compiled data annually on membership of county farm bureaus. The figures of the California Farm Bureau Federation (table 2, col. 2) are usually lower than those compiled in the office of the Director of Agricultural Extension, because the latter figures are based upon county membership dues paid, whereas the figures of the California Farm Bureau Federation are based on state and national dues paid. Several of the counties do not pay to the California Farm Bureau Federation state and national dues for all their members. The California Farm Bureau Federation is making special efforts to collect dues for all members registered with county farm bureaus.

Regional and County Distribution of Farm-Bureau Membership, 1931.—The San Joaquin Valley region had more county-farm-bureau members (based on payment of state dues) than any of the other three major regions (table 3 and fig. 1). This might be expected since the San Joaquin Valley region contains more farmers than any of the other regions. Next in order of number of county-farm-bureau members come

[14] Minutes of organization meeting of the California Farm Bureau Federation, October 22 and 23, 1919.

the south coast region, the Sacramento region, and the Bay region. However, when compared as to the percentages which farm-bureau members were of the numbers of farmers (1930), the counties of the Sacramento Valley led, in 1931, the counties of the south coast took second place, and the counties of the San Joaquin Valley and the Bay region occupied third and fourth places respectively.

TABLE 2

NUMBER OF FARM-BUREAU MEMBERS IN CALIFORNIA, 1917–18 TO 1931–32

Fiscal year ending November 30	Number as reported by county farm advisors	Number as reflected by payment of state dues	Difference
	1	*2*	*3*
1917–18*	19,020	.....†	.....
1918–19	20,389	.....†	.....
1919–20	24,168	10,794	13,374
1920–21	26,534	17,712	8,822
1921–22	.....‡	23,774	.....
1922–23	27,398	26,041	1,357
1923–24	22,803	20,953	1,850
1924–25	23,155	20,267	2,888
1925–26	23,367	19,958	3,409
1926–27	23,303	19,431	3,872
1927–28	23,886	20,507	3,379
1928–29	22,880	18,979	3,901
1929–30	24,910	20,421	4,489
1930–31	23,551	21,025	2,880
1931–32	23,796	20,616	3,180

* Earlier years not available.

† The state Federation was not formed until 1919.

‡ Not available.

Sources of data:

Col. 1: Records in Office of Director of Agricultural Extension, College of Agriculture, University of California, Berkeley.

Col. 2: Annual Report of the Secretary-Treasurer of the California Farm Bureau Federation for the year ending October 31, 1932.

Col. 3: Col. 1—col. 2.

County-farm-bureau memberships ranged, in November, 1931, from 50 in Shasta County to 2,331 in San Joaquin County, while the average for the 41 counties was 512.8 members. Four counties with a membership of 1,000 or more per county had together 6,656 members, or 31.6 per cent of the entire membership for the state. These counties were Los Angeles, Orange, San Joaquin, and Tulare. Los Angeles and Orange counties are in the south coast region, while San Joaquin and Tulare counties are in the San Joaquin Valley. Eleven counties with a membership of 500 to 999 per county contained a total of 7,418 members, or 35.3 per cent of the state's total. Of these, Butte, Sutter, and Yolo counties are in the Sacramento Valley; Fresno and Stanislaus in the San

Joaquin Valley; Sonoma in the Bay region; and Ventura in the south coast region. The other four of these eleven counties were Riverside, San Bernardino, San Luis Obispo, and Santa Barbara. The first two are inland counties in southern California and the last two are coast counties

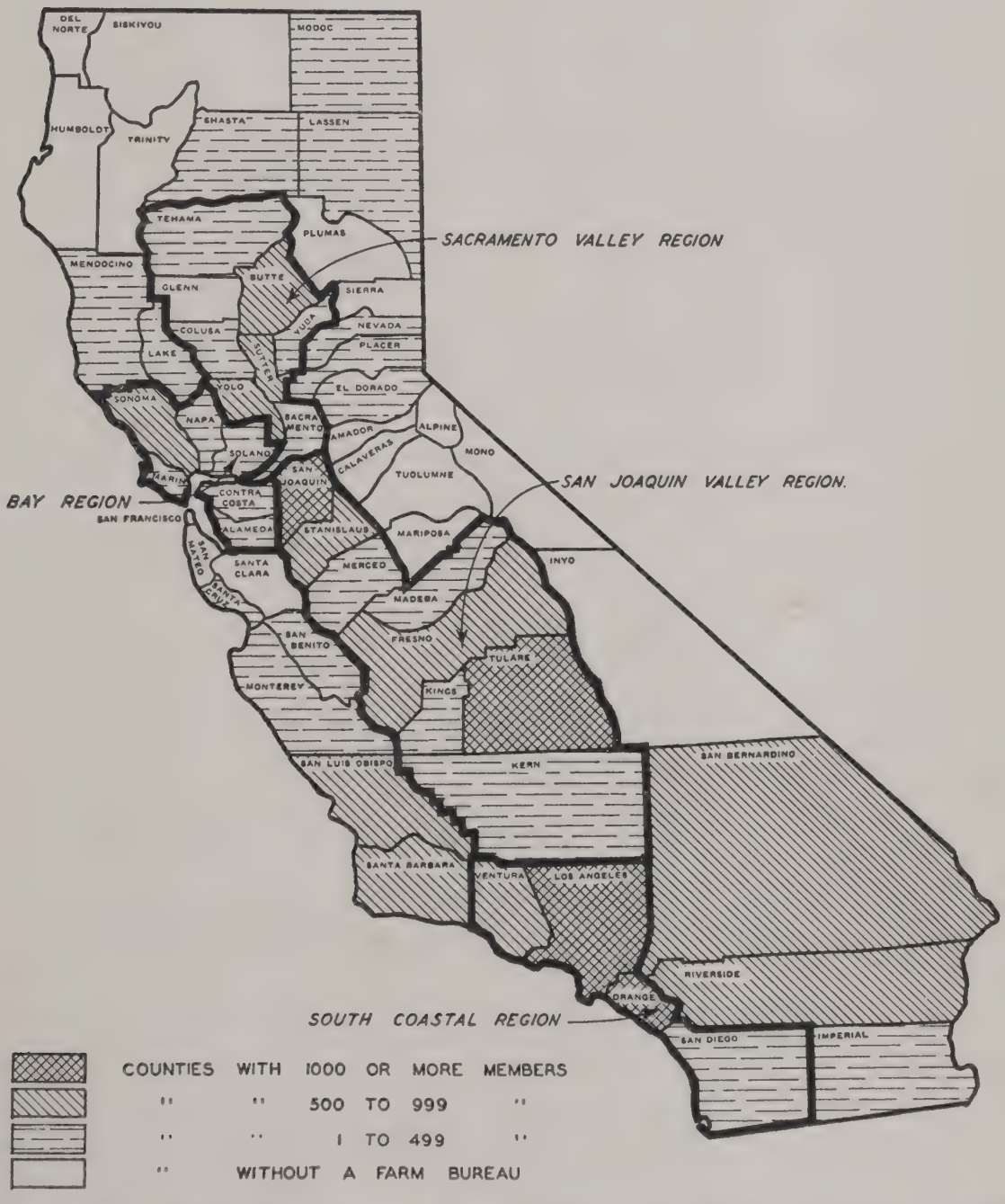


Fig. 1.—Distribution of county farm bureaus in California. Forty-one counties have county farm bureaus. Boundaries of the major agricultural regions in California are indicated by heavy black lines.

located north of the south coast region. The remaining 26 county-farm-bureau counties with less than 500 members per county had a combined total of 6,952 members, or 33.1 per cent of all the members. These counties were to be found in all regions of the state (table 3 and fig. 1).

TABLE 3

COUNTY AND REGIONAL FARM-BUREAU MEMBERSHIP IN CALIFORNIA AS REFLECTED BY PAYMENT OF STATE DUES, FOR THE FISCAL YEARS* 1919–20 TO 1930–31

Region and county	1919–1920	1920–1921	1921–1922	1922–1923	1923–1924	1924–1925	1925–1926	1926–1927	1927–1928	1928–1929	1929–1930	1930–1931	Number of farmers, 1930	Farm-bureau members as percentage of farmers
All	10,794	17,712	23,774	26,041	20,953	20,267	19,958	19,431	20,507	18,979	20,421	21,025	121,335	17.3
South coast	2,162	4,014	4,589	4,563	3,459	3,940	4,089	2,667	3,882	3,964	3,832	4,324	23,171	17.7
Los Angeles	1,261	1,901	1,903	1,681	1,315	1,221	1,555	1,071	1,791	1,582	1,392	1,612	12,653	12.7
Orange	551	667	1,710	1,320	1,171	1,432	1,523	810	1,254	1,344	1,313	1,647	4,960	33.2
San Diego	350	1,094	788	1,200	783	717	321	100	75	214	220	305	3,902	7.8
Ventura	.....	352	188	362	190	570	690	686	762	824	907	760	1,656	45.9
San Joaquin Valley	2,870	3,444	6,368	6,370	5,975	5,615	5,991	5,855	4,288	5,082	5,782	6,060	38,873	15.6
Fresno	460	560	2,043	1,463	494	500	870	853	870	638	824	720	10,334	7.0
Kern	.....	.....	67	105	1,015	811	840	518	600	506	357	309	2,397	12.9
Kings	467	638	1,000	903	761	367	400	390	381	327	361	380	2,156	17.6
Madera	167	325	510	445	361	436	438	360	325	358	346	243	1,529	15.9
Merced	407	300	.....	591	701	375	986	725	627	200	180	495	3,830	12.9
San Joaquin	567	541	869	884	989	738	761	690	959	1,216	1,920	2,331	5,730	40.7
Stanislaus	565	771	438	438	638	405	466	846	526	425	486	517	5,743	9.0
Tulare	706	947	1,441	2,132	1,016	1,983	1,530	1,473	1,493	1,412	1,308	1,065	7,154	14.9
Sacramento Valley	1,365	1,907	2,879	3,721	3,400	3,068	3,356	3,015	3,010	2,837	3,117	3,052	14,594	20.9
Butte	.....	.....	434	543	389	281	333	316	319	366	428	501	2,603	19.2
Colusa	.....	.....	.....	.....	99	161	252	238	320	336	302	289	894	32.3
Glenn	367	546	142	506	363	238	244	54	53	18	18	4†	1,463‡	.....
Sacramento	305	522	520	551	450	375	360	200	316	325	282	296	3,882	7.6
Sutter	267	210	524	788	694	711	817	830	725	666	751	561	1,758	31.9
Tehama	245	334	487	449	550	418	393	404	310	212	400	405	1,805	22.4
Yolo	79	295	438	707	683	632	722	736	707	722	737	788	1,641	48.0
Yuba	102	.....	334	177	172	252	235	237	260	192	199	208	548	38.0

TABLE 3—*(Concluded)*

Region and county	1919–1920	1920–1921	1921–1922	1922–1923	1923–1924	1924–1925	1925–1926	1926–1927	1927–1928	1928–1929	1929–1930	1930–1931	Number of farmers, 1930	Farm-bureau members as percentage of farmers
Bay region	1,078	2,791	3,162	2,794	2,378	2,185	1,734	2,115	2,114	1,933	2,112	2,131	22,124	9.6
Alameda	172	578	423	128	90	94	65	84	100	110	132	113	2,627	4.3
Contra Costa	100	100	534	414	457	311	131	125	105	123	128	364	1,890	19.2
Marin	.....	.....	202	191	267	273	338	358	329	338	215	189	690	27.4
Napa	543	270	457	510	264	427	338	397	410	370	395	384	1,686	22.8
Solano	77	419	610	386	336	288	243	267	331	345	371	365	1,479	24.7
Sonoma	186	1,424	936	1,165	964	792	619	884	839	647	871	716	6,562	10.9
All other	3,319	5,556	6,776	8,593	5,741	5,459	4,788	5,779	7,213	5,163	5,578	5,458	36,914	14.8
El Dorado	160	158	253	225	174	132	131	85	57	98	73	85	886	9.6
Humboldt	200	361	245	217	163	46	194	99	25	1	.....	.....	2,045‡	0.0
Imperial	554	.....	732	1,370	625	979	166	399	300	515	415	360	3,176	11.3
Inyo	.....	.....	.....	495	176	123	106	51	.....	.....	.....	.....	218‡	0.0
Lake	.....	.....	.....	.....	.....	230	223	255	319	128	312	260	1,057	24.6
Lassen	.....	.....	.....	262	215	65	158	376	279	285	200	210	472	44.5
Mendocino	212	367	314	279	415	402	250	482	511	466	564	494	1,672	29.5
Modoc	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	74	77	621	12.4
Monterey	210	205	758	594	253	404	464	245	237	226	281	186	1,891	9.8
Nevada	179	216	162	156	116	97	127	153	121	66	67	89	539	16.5
Placer	125	433	457	537	507	484	523	367	395	341	288	131	1,628	8.0
Riverside	437	893	672	564	367	483	456	478	682	750	807	877	4,746	8.5
San Benito	.....	.....	428	447	407	329	271	351	318	323	219	361	1,077	33.5
San Bernardino	267	1,000	1,182	646	656	431	433	447	457	455	539	531	7,062	7.5
San Luis Obispo	.....	.....	68	334	179	226	325	1,245	1,177	719	738	819	1,923	42.6
Santa Barbara	.....	250	514	596	399	396	455	300	507	549	510	628	1,408	44.6
Santa Cruz	161	609	531	730	537	459	506	446	335	241	431	300	1,855	16.2
Shasta	345	426	460	550	452	173	.....	.....	.....	.....	60	50	1,213	4.1
Number of counties reporting	*32*	*32*	*38*	*41*	*42*	*43*	*42*	*42*	*41*	*40*	*42*	*41*	.....	.....
Average per county	337.3	553.5	625.6	635.1	498.9	471.3	475.2	462.6	500.2	474.5	486.2	512.8	3,014.6	.....

* Fiscal year extends from November 1 to October 31. † Omitted in 1930-31 when enumerating county farm bureaus. ‡ Not included in total number of farms.

Sources of data:
County-farm-bureau membership data: From the 1931 Annual Report of the Secretary of the California Farm Bureau Federation.
Number of farmers: From U. S. Dept. Commerce Bur. of the Census. Fifteenth Census of the United States, 1930. Agriculture. 1932. The figures in the Census are for farms. For the purpose of this study farms are regarded as synonymous with farmers.

Farm-Bureau Members and Numbers of Farmers.—In 1931 almost 90 per cent of the farmers in California were in counties that had county farm bureaus. The 17 counties that had no farm bureaus contained 14,341 farmers (1930), over 6,000 of whom were in Santa Clara County.[15] The 4, 11, and 26 counties which had 1,000 members and over, 500–999 members, and under 500, respectively, have been classified according to the percentage that farm-bureau members were of the number of farmers (1930 Census), as well as according to numbers of farm-bureau members. Two of the four large-membership counties had farm-bureau members equal to 20 per cent or more of their numbers of farmers and the remaining two were above 10 per cent. Six of the 11 middle-membership counties fell below 20 per cent, with 3 under 10 per cent. Sixteen of the 26 small-membership counties had farm-bureau members representing less than 20 per cent of the numbers of farmers. In general, as the sizes of the farm bureaus decreased, their proportional strength when compared with the numbers of farmers also decreased (table 4).

TABLE 4

COMPARISON OF COUNTY FARM BUREAUS BASED ON NUMBER OF MEMBERS AND PROPORTION OF FARMERS WHO ARE MEMBERS

(Fiscal year ending November 30, 1931)

Farm-bureau members as per cent of farmers in counties	Number of counties in each class	Classification of counties according to number of farm-bureau members		
		1,000 and over	500-999	Under 500
Totals	41	4	11	26
40 and over	6	1	4	1
30–39	5	1	1	3
20–29	6	0	0	6
10–19	14	2	3	9
Under 10	10	0	3	7

Source of data: Table 3.

Size of County Farm Bureaus and Fluctuations in Membership.—In 1922–23 the 41 county farm bureaus had an average of 635 members. The following year 42 counties averaged only 499 members, a drop of 136. The drop in total membership that year was over 5,000. In 1930–31, 41 counties reported an average membership of 513, the highest since 1922–23 (table 5). When classified according to numbers of members the various county farm bureaus showed considerable difference in membership fluctuations. During the years 1923–24 to 1930–31, the four

[15] The grange has a strong membership in Santa Clara County.

county farm bureaus which had 1,000 or more members in 1930–31 had increased membership from an average of 1,123 to 1,664; the 11 which had 500–999 members had increased from an average of 514 to 674; and the 26 which had less than 500 members decreased from an average of 400 to 267 (table 5). Since the smaller farm bureaus generally have secured a lower proportion of the farmers of their counties than the larger ones and since they have lost members while the larger farm bureaus have gained, it seems clear that the former group needs especial attention if the California farm bureau as a whole is to maintain its member-

TABLE 5

Average Members in the California Farm Bureau, by Groups of Counties, 1919–20 to 1930–31

Fiscal year	State average membership		Average in group I*		Average in group II*		Average in group III*	
	Number of counties	Average	Number of counties	Average	Number of counties	Average	Number of counties	Average
1919–20	32	337	4	771	7	327	21	259
1920–21	32	554	4	1,014	8	719	20	395
1921–22	38	626	4	1,481	11	676	23	453
1922–23	41	635	4	1,504	11	691	26	478
1923–24	42	499	4	1,123	11	514	27	400
1924–25	43	471	4	1,344	11	493	28	338
1925–26	42	475	4	1,342	11	562	27	311
1926–27	42	463	4	1,011	11	693	27	288
1927–28	41	500	4	1,374	11	688	26	286
1928–29	40	475	4	1,389	11	615	25	267
1929–30	42	486	4	1,483	11	691	27	256
1930–31	41	513	4	1,664	11	674	26	267

* Group I, counties having 1,000 members; group II, those having 500-999; group III, those having under 500 members, for fiscal year ending November 30, 1931 (table 4). The county farm bureaus are kept in the same groups through the years 1919-20 to 1930-31 regardless of fluctuations in their membership.

Source of data: Table 3.

ship in all of the counties now organized. The differences between counties in total number of farmers, type of agriculture, population in city centers, and other social and economic conditions greatly complicate the question of the proportion of farmers which it is desirable for each county farm bureau to enroll. For instance, the Lassen County Farm Bureau, except for two years, has maintained a membership between 200 and 300, which is between 40 and 60 per cent of the number of farmers in the county, whereas the membership of the Los Angeles County Farm Bureau, while it has not fallen below 1,000 since 1919–20, has never exceeded 16 per cent of the farmers in the county (table 6). Lassen County is mountainous and is largely dependent on cattle-raising and lumbering. It is entirely rural, the largest center having a popula-

tion of 1,358. Los Angeles County, on the other hand, has a large metropolitan population and its agriculture produces a wide range of commodities. While the Lassen County Farm Bureau operates largely by volunteer effort, the Los Angeles County Farm Bureau employs a full-time executive secretary with a field helper and stenographer. Lassen County has only one farm advisor, whereas a staff of seven farm advisors is at the service of farmers in Los Angeles County. The importance of numbers has made it necessary for the Lassen County Farm Bureau to enroll a relatively high proportion of the farmers of the county, while the Los Angeles County Farm Bureau, with over 12,000 farmers from whom to canvass members, has never enrolled as high as 20 per cent of that number and yet has maintained a large membership. It is doubtful whether the membership of Lassen County Farm Bureau can be increased greatly, whereas there would seem to be much possibility for expansion in Los Angeles County, notwithstanding its greater numerical strength.

Yolo County illustrates another aspect of the problem of size of membership. While the number of farmers in this county is decreasing, the county farm bureau has maintained a membership of about 700 since 1922–23. The county's agricultural products include barley, wheat, rice, sheep, wool, and almonds. More than 75 per cent of its land is in farms, which average a little less than 300 acres in size. The county seat is a major rural trade center of over 5,000. Over 75 per cent of its population is rural and it is largely homogeneous. This county farm bureau with approximately 700 members representing over 40 per cent of the farmers of the county seems to have reached stability as regards the number of members,[16] although the proportion of members to farmers is increasing largely because of a decrease in the number of farmers.

Several county farm bureaus have succeeded in noticeably increasing their membership strength during the past few years. The most noteworthy among these is the San Joaquin County Farm Bureau, which has increased its membership from 567 in 1919–20 to 2,331 in 1930–31, the biggest numerical increase having taken place since 1927–28.[17] This county was recognized by the American Farm Bureau Federation as having the largest county-farm-bureau membership in the United States in 1929–30 and 1930–31. The county farm bureau employed a full-time secretary, and farmers in the county had the services of several farm advisors and a home demonstration agent.

[16] Center attendance has also remained more or less stable around 5,000.

[17] Attendance at center meetings also increased from 3,876 in 1919–20 to 18,856 in 1930–31.

TABLE 6

Number of Farmers in Selected Counties Belonging to County Farm Bureaus, 1919–20 to 1930–31

Fiscal year	Number of farmers in county				Number of farm-bureau members in county				Farm-bureau members as percentage of all farmers in county			
	Lassen	Los Angeles	Yolo	San Joaquin	Lassen	Los Angeles	Yolo	San Joaquin	Lassen	Los Angeles	Yolo	San Joaquin
1919–20	606	12,444	1,613	4,500	.....	1,261	79	567	.....	10.1	4.9	12 6
1920–21	570	12,432	1,661	4,623	.....	1,901	295	541	.....	15.3	17.9	11.7
1921–22	524	12,420	1,709	4,746	.....	1,903	438	869	.....	15.3	25.6	18.3
1922–23	488	12,408	1,757	4,869	262	1,681	707	884	53.7	13.5	40.2	18.2
1923–24	452	12,396	1,805	4,992	215	1,315	683	989	47.6	10.6	37.8	19.8
1924–25	425	12,381	1,852	5,115	65	1,221	632	738	15.3	9.9	34.1	14.4
1925–26	434	12,435	1,810	5,236	158	1,555	722	761	36.4	12.5	39.9	14.5
1926–27	443	12,489	1,768	5,361	376	1,071	736	690	84.9	8.6	41.6	12.9
1927–28	452	12,544	1,726	5,484	279	1,791	707	959	61.7	14.3	41.0	17.5
1928–29	462	12,599	1,784	5,607	285	1,582	722	1,216	61.7	12.6	40.5	21.7
1929–30	472	12,653	1,641	5,730	200	1,392	737	1,920	42.4	11.0	44.9	33.5
1930–31	482	12,707	1,599	5,853	210	1,612	788	2,331	43.6	12.7	49.3	39.8

Sources of data:

Number of farmers: U. S. Dept. Commerce, Bur. of the Census, Fourteenth and Fifteenth censuses of the United States, Agriculture; and the 1925 Agricultural Census. Figures for the intervening years were obtained by interpolation. Figures in censuses are for farms. For purposes of comparison the number of farms and farmers are regarded as identical in this table.

Number of farm-bureau members: table 3.

Farm-Center Meetings and Attendance.—From the first it was the policy of the California Agricultural Extension Service and the county farm bureaus to organize the individual members in each county into local groups or centers. Beginning in Humboldt County in 1913, farm centers increased rapidly in numbers as new farm bureaus were organized. There were over 450 centers in existence in 1919 when the California Farm Bureau Federation was organized (table 7). Farm centers continued to increase up to 1923–24, when there were 568 centers altogether. Since then the number of farm centers has decreased steadily. It is probable that improvement in transportation facilities and highways has had the effect of widening the areas covered by individual centers and consequently of decreasing the number of farm centers.

TABLE 7

FARM-CENTER-MEETING ATTENDANCE, CALIFORNIA, 1919–20 TO 1930–31

Fiscal year	Number of farm centers	Number of center meetings held	Total attendance at center meetings	Average attendance at center meetings	Average annual attendance per farm center	Average number of meetings per farm center
1919–20*	466	4,483	186,055	41	399	10
1920–21	475	4,822	199,553	41	420	10
1921–22	481	4,011	164,681	41	342	8
1922–23	537	3,762	159,457	42	297	7
1923–24	568	3,402	157,072	46	277	6
1924–25	536	3,452	161,549	46	301	6
1925–26	487	3,395	172,912	51	355	7
1926–27	481	3,115	167,022	54	347	6
1927–28	456	2,847	151,564	53	332	6
1928–29	393	2,718	149,865	55	381	7
1929–30	385	2,707	152,987	57	397	7
1930–31	369	2,813	168,505	60	457	8

* Information not available prior to 1919-20.

Source of data:

Statistical Summaries, Office of the Agricultural Extension Service, College of Agriculture, Berkeley, California.

It was intended by the sponsors of the California farm bureau that farm centers would meet monthly. While a few farm centers do meet once each month during the year, many centers have found it impracticable to hold meetings during the months of July and August, when many farmers and their families are either away on vacation or engaged in harvesting their crops and fruit. A number of farm centers meet only a few times a year. The number of farm-center meetings held reached the peak in 1920–21 when the number of meetings per center averaged 10 for the year. Since then the number of center meetings held annually has declined more or less continuously, the decline up to 1928–29 having been more rapid than the decline in the number of farm cen-

ters. This, of course, reduced the average number of meetings a year per farm center. Since 1928–29 the number of meetings per center has tended to increase.

The total annual attendance at farm center meetings reached a peak in 1920–21, when the attendance exceeded 199,000. In 1921–22 attendance declined by some 30,000 and continued to decline till 1923–24, when attendance was only 157,072. There was some recovery during the next two years. Attendance, however, declined again from 1926–27 to 1928–29. The years 1929–30 and 1930–31 showed some improvement in attendance. While the total attendance has declined since 1919–20, the attendance per meeting increased practically continuously right up to 1930–31.

Farm-Bureau Membership and Attendance at Center Meetings.—Attendance at farm-center meetings reached a peak in 1920–21 (table 7); county-farm-bureau membership reached a peak two years later in 1923 (table 2). A second high point in farm-center attendance was reached in 1925–26; another high point in farm-bureau membership was reached two years later in 1927–28. Two low points in farm-bureau membership were recorded in the years 1923–24 and 1928–29. These were also years of low attendance at farm-center meetings. While chronological relation cannot be predicted with any degree of certainty from so small a number of years, it would nevertheless appear that there is a definite relation between attendance at farm-center meetings and farm-bureau membership. It is not necessary to infer a causal relation between attendance changes and membership changes. It probably would be more correct to assume that attendance at meetings is an indicator of interest in farm centers and indirectly of interest in the activities of the farm bureau. Center meetings serve not only as an activity for those who already are in membership with the farm center, but also as a magnet to draw nonmembers into attendance. Interest in the farm center thus aroused would in many cases culminate after a while (apparently one to two years) in full membership in the farm bureau. Loss of interest in the farm center, as indicated by a decline in attendance, on the other hand, may be a symptom of a more general decline of interest in the activities of the county farm bureau, and may be attended by a failure to pay dues and maintain membership standing.

COMPARISON OF MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS[18]

The object of these comparisons is to furnish a description of the place or position occupied by farmers' general-purpose organizations in the rural life of the state. They serve to answer such questions as:

1. Do the better, average, or poorer farmers of the state support general-purpose organizations?
2. Are members of general-purpose organizations as likely to be members of other kinds of organizations as nonmembers?
3. Are members of general-purpose organizations as likely to be members of special-purpose organizations as nonmembers?
4. Is there a difference between members and nonmembers as to interest in questions of public importance?

Method of Collecting Data.—During the course of this investigation 440 farmers living in 15 localities in the four major agricultural regions of the state were visited and interviewed, the information obtained from each farmer being entered on a mimeographed questionnaire. The 15 localities are situated in eight different counties, two counties, Los Angeles and Orange, being in the south coast region; three, Tulare, Fresno, and San Joaquin, in San Joaquin Valley region; one, Yolo, in the Sacramento Valley region; and two, Sonoma and Santa Clara, in the San Francisco Bay region. The counties in each region were selected because of their importance agriculturally (table 8) and because they contained relatively large numbers of members of the farm bureau, the grange (Patrons of Husbandry), and the Farmers' Union. In 1931 the eight counties contained 8,900 farm-bureau members, or 43 per cent of the total, 2,500 members, or 28 per cent of the membership of the grange in California, and practically all the members of the Farmers' Union in the state. The latter organization did not have a very large state membership in 1931.

In each county, except one, two localities were selected for farm-to-farm visitation. These localities also were selected because of their importance agriculturally and because they contained an average or a greater than average proportion of farmers who were members of general and special-purpose organizations. Each locality also represented a local unit of the farm bureau, grange, or Farmers' Union. The number of farmers visited in each locality ranged from 14 to 62, according to the variety of commodities produced and their relative importance in

[18] Includes the farm bureau, the grange (Patrons of Husbandry), and the Farmers' Union.

TABLE 8

Population, Number, Size, Value of Farms, and Principal Agricultural Products of Eight Selected Counties, 1930

Region and county	Population					Size and value of farms				Principal agricultural commodity†
	Numbers			Per cent of total population		Number	Per cent of land in farms	Average acres per farm	Value of land and buildings per acre	
	Total	Rural	Farm*	Rural	Farm					
California, total	5,677,251	1,516,655	579,350	26.7	10.2	135,676	30.6	224.4	$112.33	.....
Eight counties, total	2,882,911	623,085	220,842	21.6	7.7	55,271	.....	.....	.....	.....
South coast:										
Orange	118,674	54,741	17,909	46.1	15.1	4,960	56.6	58.1	950.13	Oranges (1), persimmons (1), lemons (2), walnuts (3)
Los Angeles	2,208,492	282,717	33,169	12.8	1.5	12,653	20.0	41.7	906.70	Lemons (1), walnuts (1), milk (1), oranges (2), vegetables (2), poultry products (2), hogs (3)
San Joaquin Valley:										
Tulare	77,442	49,138	35,104	63.4	45.3	7,154	38.4	166.7	126.66	Olives (1), cattle and calves (1), figs (2), all grapes (2), raisin grapes (2), cotton (2)
Fresno	144,379	80,412	48,416	55.7	33.5	10,334	39.2	144.4	95.74	Figs (1), all grapes (1), raisin grapes (1), horses and mules (1), peaches (2), table grapes (2), cattle and calves (2), cotton (3)
San Joaquin	102,940	44,360	26,577	43.1	25.8	5,730	75.3	121.8	198.48	Wine grapes (1), table grapes (1), potatoes (1), sugar beets (1), cherries (2), barley (2), all grapes (3), wheat (3), alfalfa (3), horses (3)
Sacramento Valley:										
Yolo	23,644	18,102	8,720	76.6	36.9	1,641	75.2	297.5	138 40	Barley (1), almonds (1), rice (4), sheep (4)
Bay region:										
Sonoma	62,222	43,341	25,186	69.6	40.5	6,562	76.6	118.1	138.56	Poultry products (1), apples (2), prunes (2), cherries (3), wine grapes (3)
Santa Clara	145,118	50,274	25,761	34.6	17.8	6,237	60.8	82.9	$299.76	Apricots (1), prunes (1), cherries (1)

* Rural population on farms, not including farm families in villages, towns. and cities.

† Numbers after products indicate rank of county as compared with other counties in the state with regard to value of product.

Source of data:
U. S. Dept. Commerce Bur. of the Census. Fifteenth Census of the United States, 1930. Agriculture. 1932.

the agriculture of the state (table 9). Members and nonmembers visited lived side-by-side in the same localities.[19] The extra-familial environment is thus identical for members and nonmembers. Members were defined as those who had paid their dues for the year (1930–31). Some members had but recently joined a general-purpose farmers' organization; some nonmembers had but recently discontinued membership. There were, however, very few ex-members of farmers' organizations among the farmers visited. In the circumstances nonmembers may be regarded as affording a fair representation of farmers who had remained outside general-purpose farmers' organizations.

Numbers of Members and Nonmembers.—Of the 440 farmers who were visited and who supplied the data used in a comparison of members and nonmembers, 301 belonged to a farmers' general-purpose organization, 139 did not.[20] Of the 301 members, 259 belonged to the farm bureau, 24 to the grange, 5 to the Farmers' Union, 11 to both the farm bureau and the grange, and 2 to the grange and Farmers' Union. Taking account of duplications, there were 270 farm-bureau members, 37 grange members, and 7 Farmers' Union members.

Comparisons Based on Extent of Farming Operations.—Since each locality in the eight counties contained both members and nonmembers, and both groups produced the commodities listed in table 9, it cannot be said that producers of any selected commodities, more than others, supported general-purpose organizations. There appear, however, to be significant differences between members and nonmembers in the extent and nature of farming operations.

The farms of members averaged 132.8 acres, of which 57.2 acres were irrigated, whereas the farms of nonmembers averaged 87.4 acres, of which 36.7 acres were irrigated. A frequency distribution of size of farms shows a similar relation (table 10).

As the average size of farms operated is greater for members than for nonmembers, it can be expected that the value of commodities sold and the value of farm supplies purchased would be greater for members than for nonmembers. Tables 11 and 12 show this to be the case. The average return per acre for products sold was $53.10 for members and $36.40 for nonmembers. The per-acre cost of supplies was $11.54 for members and $8.60 for nonmembers.

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[19] In one locality no nonmembers were visited owing to the enumerator's shortage of time and his method of procedure in that one locality. The chief commodity produced in this locality was citrus fruit and since a number of citrus growers are among nonmembers elsewhere visited the omission does not seriously affect the value of the sample. In another locality only 1 nonmember was found in a block of 22 farmers.

[20] Of the 440 farmers, 376 were owners, 19 were renters, and 4 were managers of farms; 41 of the owners also rented additional land.

TABLE 9

Localities Selected for Farm Visitation with Principal Products and Size of Farm, 1931

Region	County	Name of locality	Organizational connection	Principal agricultural products	Number of farms visited	Average acreage	
						In farms	Under irrigation
South coast	Orange	Foothill	Farm center	Citrus fruits	32	15.1	14.3
		Garden Grove	Farm center	Lima beans	21	190.2	175.7
	Los Angeles	Whittier	Farm center	Walnuts, dairying	31	28.0	24.3
		San Fernando	Farm center	Citrus, poultry products	31	28.1	24.0
San Joaquin Valley	Tulare	Lindsay	Farm center	Citrus fruits, olives	16	34.9	33.7
	Fresno	Riverdale	Farm center	Dairying	14	470.7	126.4
		Selma	Farm center	Raisin grapes, figs	16	38.6	36.8
	San Joaquin	Nile Garden	Farm center	Dairying, grain	35	93.9	75.0
		Bruella	Farm center	Table grapes	43	54.4	36.4
Sacramento Valley	Yolo	Clarksburg	Farm center	Sugar beets, asparagus	22	170.9	160.1
		Plainfield	Farm center	Barley, wheat, almonds, cattle, sheep, dairy products	62	415.1	68.4
Bay region	Sonoma	Cunningham-Sebastopol	Farm center and subordinate grange	Apples, cherries, poultry products	27	14.2	0.5
		Petaluma	Farm center and subordinate grange	Poultry products	26	11.9	0.4
	Santa Clara	Campbell	Subordinate grange	Prunes, apricots, poultry products	48	35.0	29.7
		Moreland	Local Farmers' Union	Walnuts, prunes, apricots	16	41.1	21.6
Total					440	118.5	50.6

TABLE 10

FREQUENCY DISTRIBUTION OF SIZE OF FARMS OWNED BY 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, 1931

Acreage	Members		Nonmembers	
	Number	Per cent	Number	Per cent
Total	301=100		139=100	
0- 19	90	30	69	49
20- 39	64	21	26	19
40- 59	36	12	15	11
60- 79	19	6	7	5
80- 99	13	4	7	5
100-119	8	3	1	1
120-139	6	2	0	0
140-159	7	2	1	1
160-179	2	1	1	1
180-199	3	1	0	0
Over 200*	53	18	12	8

* From 200 to 5,100.

TABLE 11

VALUE OF COMMODITIES PRODUCED FOR SALE AND OF FARM SUPPLIES PURCHASED, 1931, BY 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, BY REGIONS

Region	Members			Nonmembers		
	Number	Total value	Average value per farm	Number	Total value	Average value per farm
Value of commodities produced for sale						
All	301	$2,121,306	$ 7,047	139	$ 441,540	$ 3,177
South coast	83	679,495	8,187	32	68,444	2,108
San Joaquin Valley	91	310,715	3,414	33	60,485	1,833
Sacramento Valley	67	770,500	11,500	17	108,355	6,374
Bay region	60	$ 367,555	$ 6,126	57	$ 205,256	$ 3,601
Value of farm supplies purchased*						
All	301	$ 461,286	$ 1,532	139	$ 104,605	$ 752
South coast	83	184,554	2,224	32	16,675	521
San Joaquin Valley	91	61,423	675	33	7,295	221
Sacramento Valley	67	49,993	746	17	13,700	806
Bay region	60	$ 165,316	$ 2,755	57	$ 66,935	$ 1,174

* These include chicken feed, hay and other feeds, gasoline, oil, fertilizers, spray materials, sacks, seeds, and other supplies.

Members and nonmembers were compared as to bank loans made for production purposes. Each farmer's estimate was based on the experience of 1931 but was made in anticipation of needs for 1932. Those who did not plan to borrow in 1932 were not included in the estimates; doubtless some of those were unable to borrow, but others planned their operations to avoid borrowing. The estimates of needs were based upon the largest amount needed at any one time during the year. Among the 440 farmers interviewed, 181 gave such estimates. Of these, 130 were members, and their estimates totaled $266,920, or an average of $2,053; the remaining 51 were nonmembers, whose estimates totaled $69,731, or $1,367 each. The bank loans anticipated averaged $15.46 an acre for

TABLE 12

Frequency Distribution of Value of Commodities Produced for Sale, 1931, by 440 Members and Nonmembers of Farmers' General-Purpose Organizations

Value in dollars	Members		Nonmembers	
	Number	Per cent	Number	Per cent
Totals	301	100	139	100
0– 999	51	17	41	30
1,000– 1,999	50	17	37	27
2,000– 2,999	49	16	25	18
3,000– 3,999	28	9	8	6
4,000– 4,999	19	6	7	5
5,000– 5,999	18	6	4	5
6,000– 6,999	16	5	4	3
7,000– 7,999	11	4	2	1
8,000– 8,999	4	1	2	1
9,000– 9,999	6	2	2	1
10,000–10,999	7	2	0	0
11,000–11,999	2	1	0	0
12,000–12,999	1	1	1	1
13,000 and over	39	17	5	4

members, and $15.64 an acre for nonmembers. The production-loan load per acre was practically the same for the two groups.

It was thus found that farmers who support general-purpose organizations operate larger acreages more intensively and secure a greater gross return in dollars per farmer than farmers who do not support them.[21]

Comparisons Based on Other Organizational Affiliations.—Members of farmers' general-purpose organizations also supported other organ-

[21] Compare: Manny, T. B., and R. C. Smith. The Ohio Farm Bureau Federation from the farmer's viewpoint. U. S. Dept. Agr. Bur. Agr. Econ. in cooperation with Ohio State University, Dept. of Rural Econ. and the Federal Farm Board. Page 112, table 71. (Mimeo.)

izations to a greater extent than nonmembers. Farmers who were members of general-purpose organizations averaged 5.7 affiliations, 1.0 of which represents membership in the general-purpose organizations themselves. The members' affiliations with other organizations therefore averaged 4.7. Farmers who were nonmembers averaged 3.2 affiliations. A comparison of agricultural regions shows that the relative differences between members and nonmembers were greater in the regions of the great interior valleys than in the regions containing the metropolitan areas of Los Angeles and San Francisco (table 13). Twelve farmers reported no affiliations whatsoever. Obviously, these were nonmembers. Nonmembers had from 0 to 9 affiliations, and members from 1 to 12. Considerably more than one-half of the members had 5 or more affiliations, while almost one-half of the nonmembers had 3 or less (table 14).

TABLE 13

ORGANIZATION AFFILIATIONS OF 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, BY REGIONS, 1931

Region	Members			Nonmembers			Ratio of averages†
	Number	Affiliations*	Average*	Number	Affiliations	Average	
	1	*2*	*3*	*4*	*5*	*6*	*7*
Total	301	1,704*	5.7	139	439	3.2	1.8
South coast	83	523	6.3	32	136	4.3	1.5
San Joaquin Valley	91	494	5.4	33	79	2.4	2.2
Sacramento Valley	67	291	4.3	17	30	1.8	2.4
Bay region	60	396	6.6	57	194	3.4	1.9

* These include affiliations with general-purpose organizations. Including 13 duplications, there were 314 affiliations with general-purpose organizations, or 1.0 per member. The average affiliations with other organizations is therefore approximately 1 less than the average including general-purpose organizations as given in col. 3.

† Col. 3 divided by col. 6.

Members exceeded nonmembers in every kind of affiliation, both as to percentages affiliated and numbers of affiliations. Organizations were classified as: general-purpose organizations, mutual insurance companies, cooperative marketing associations, cooperative purchasing associations, lodges, and church organizations. With members, general-purpose organizations led as to percentage of farmers affiliated and mutual insurance as to numbers of affiliations. Nonmembers carried the most affiliations, in both respects, with mutual insurance companies (table 15).

The 301 members of general organizations had 815 organizational affiliations which involved attendance at meetings. Of these, 433, or 53.2 per cent, were accompanied by regularity of attendance. The 139 nonmembers had 121 affiliations which involved attendance, of which 63, or

52.1 per cent, were accompanied by regularity of attendance. The difference is not significant.

When all persons in the 301 members' families were compared with all persons in the 139 nonmembers' families, it was found that the former were more often supporters of other organizations, although nonmembers' children from 10 to 17 years of age had more affiliations per child than members' children. Membership families averaged 3.4 affiliations

TABLE 14

DISTRIBUTION OF ORGANIZATIONAL AFFILIATIONS OF 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, 1931

Number of organizational affiliations per operator	Members*	Non-members*	Number of organizational affiliations per operator	Members*	Non-members*
Totals	301	139	5	55	11
0	0	12	6	47	4
1	11	30	7	26	4
2	24	25	8	26	1
3	49	23	9	13	1
4	43	28	10 and over	7	0

* The range for members is from 1 to 12 affiliations; for nonmembers it is from 0 to 9. The average for members is 5.7 affiliations (including affiliations with general-purpose organizations) and for nonmembers 3.2.

TABLE 15

KINDS OF ORGANIZATIONAL AFFILIATIONS OF 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, 1931

Kind of organization	Number of affiliations		Per cent of farmers affiliated	
	Members	Nonmembers	Members	Nonmembers
Total	1,704	439	301=100 per cent	139=100 per cent
Farmers' general-purpose organizations	314	0	100	0
Mutual insurance companies	460	171	81	73
Cooperative marketing associations	232	90	60	56
Cooperative purchasing associations	197	57	58	37
Lodges	212	48	70	35
Church and church organizations	112	45	37	32
Others	177	28	59	20

per person (including affiliations with general-purpose organizations), and 62 per cent of the affiliations that involved attendance were accompanied by regular attendance. Nonmembership families averaged, for each person, 2.2 affiliations and attendance was regular with 59 per cent of those involving attendance (table 16).

Organizational affiliations were reported for 308 operators' wives. Since many reports were incomplete as to the number of operators whose wives were deceased, divorced, or otherwise separated from their

husbands, and as to operators who were unmarried, the number of wives without any affiliations had to be estimated on the basis of the other data reported. There were no less than 50 in this classification. More than one-half of these were nonmembers' wives. The wives of members averaged 2.2 affiliations and wives of nonmembers averaged 1.5. Wives of members had 169 affiliations in home departments, subordinate granges, or local Farmers' Unions.

TABLE 16

ORGANIZATIONAL AFFILIATIONS AND ATTENDANCE OF ALL PERSONS,* AND OF CHILDREN (10–17 YEARS OF AGE), IN 440 FAMILIES OF MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, 1931

Group	Total number	Affiliations				Attendance		
		All reporting affiliations	Per cent of total	Total affiliations	Average per person	Affiliations involving attendance	Number regularly attended†	Per cent regularly attended†
All persons in family								
Membership families	721	669	92.8	2,434‡	3.4‡	1,545	956	61.9
Nonmembership families	285	244	85.6	622	2.2	304	179	58.9
Children 10 to 17 years of age								
In membership families	105¶	78	74.3	114	1.1	114	89	78.0
In nonmembership families	43	32	74.3	63	1.5	63	41	65.0

* Operator, wife, and all children at home 10 years old or older.

† Regular attendance is defined to mean attendance at one-half or more of the regular meetings.

‡ These include affiliations with general-purpose organizations.

¶ Ninety-six children were in farm-bureau families, 5 in grange families, and 4 in Farmers' Union families.

Children between the ages of 10 and 17 in members' families averaged 1.1 affiliations, while in nonmembership families they averaged 1.5. This was the one group exception to the general rule that members exceeded nonmembers in organizational affiliations. Children in member families, however, were more regular in attendance (table 16).[22]

[22] A classification of childrens' affiliations (in membership and nonmembership families) shows that the church led as to numbers of affiliations, while 4-H Clubs and Scouts and Girl Reserves came next. Musical organizations were also important. Athletic organizations and teams occupied last place among the first five organizations. Two boys were in Smith-Hughes clubs but not all high-school agricultural students interviewed were thus enrolled.

Affiliations with Commercial Organizations.—Since mutual insurance companies, cooperative marketing associations, and cooperative purchasing associations occupied leading positions among organizations which members of general-purpose organizations supported, these kinds of affiliations were given further analysis. Affiliations of members and nonmembers with special-purpose organizations help to answer the question: To what extent do members of general-purpose organizations also support special-purpose organizations?

Mutual-insurance affiliations, which were largely with county mutual companies and automobile insurance companies, were relatively most numerous in the south coast and San Francisco Bay regions, less numerous in the San Joaquin Valley, and least numerous in the Sacramento Valley, for both members and nonmembers. The average number of affiliations per farmer affiliated for members slightly exceeded the average for nonmembers (table 17), but the difference is not significant.

The south coast and San Francisco Bay regions had higher proportions of farmers affiliated with cooperative marketing associations than the San Joaquin and Sacramento valleys. For nonmembers, proportions were highest in the south coast region and for members, in the Bay region. For both members and nonmembers, proportions were lowest in the Sacramento Valley. The average numbers of affiliations were not widely different; in three regions members exceeded nonmembers, but in the Sacramento Valley, nonmembers exceeded (table 17).

The proportional value of commodities marketed cooperatively was smaller with members than with nonmembers. Nonmembers marketed 42 per cent of the total value of commodities produced for sale through cooperative associations, while members thus marketed only 32 per cent of the value of commodities produced for sale. In the south coast region the proportional value thus marketed by nonmembers was double the proportion marketed by members. This is partly explained by the fact that members made considerable use of small pools for egg-marketing in this region. In the Sacramento and Bay regions, members exceeded nonmembers as to proportional value marketed cooperatively (table 18).

Average numbers of cooperative-purchasing affiliations were the same for members and nonmembers when each group was taken as a whole. In the south coast region and the San Joaquin Valley, members exceeded nonmembers in average affiliations; in the Sacramento Valley, nonmembers did no cooperative purchasing; and in the Bay region, average affiliations were the same for nonmembers as for members. In all regions but the south coast the percentage of members affiliated was higher than that of nonmembers (table 17).

TABLE 17

MUTUAL-INSURANCE, COOPERATIVE-MARKETING, AND COOPERATIVE-PURCHASING AFFILIATIONS OF 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, BY REGIONS, 1931

Region	Members					Nonmembers				
	Farmers			Affiliations		Farmers			Affiliations	
	Total number	Number with affiliations	Per cent affiliated	Total	Average per farmer affiliated	Total number	Number with affiliations	Per cent affiliated	Total	Average per farmer affiliated
Mutual-insurance affiliations*										
All	301	243	81	460	1.9	139	101	73	171	1.7
South coast	83	71	86	155	2.2	32	28	88	44	1.6
San Joaquin Valley	91	71	78	117	1.6	33	22	67	33	1.5
Sacramento Valley	67	47	70	81	1.7	17	10	59	16	1.6
Bay region	60	54	90	107	2.0	57	41	72	78	1.9
Cooperative-marketing affiliations										
All	301	181	60	232	1.3	139	78	57	90	1.2
South coast	83	63	76	77	1.2	32	29	91	31	1.1
San Joaquin Valley	91	54	59	71	1.3	33	16	49	16	1.0
Sacramento Valley	67	15	22	20	1.3	17	2	12	3	1.5
Bay region	60	49	82	64	1.3	57	31	54	40	1.3
Cooperative-purchasing affiliations										
All	301	174	58	197	1.1	139	52	37	57	1.1
South coast	83	66	80	78	1.2	32	30	94	34	1.1
San Joaquin Valley	91	68	75	76	1.1	33	5	15	5	1.0
Sacramento Valley	67	4	6	4	1.0	17	0	0	0	0.0
Bay region	60	36	60	39	1.1	57	17	30	18	1.1

* Mutual insurance companies include county mutual fire insurance and mutual insurance of automobiles against fire, theft, collision, and against personal liability and property damage.

On the whole, both members and nonmembers purchased one-third of their farm supplies cooperatively (table 18). The difference of 1 per cent found between the percentages of total value of supplies purchased cooperatively by members and nonmembers is not significant. In the San Joaquin Valley and Bay regions, however, members purchased cooperatively a much higher percentage of the total value of supplies than nonmembers. The reverse was true in the south coast region.

TABLE 18

Value and Percentage of Commodities Marketed Cooperatively and of Supplies Purchased Cooperatively, by 440 Members and Nonmembers of Farmers' General-Purpose Organizations, 1931

Region	Members		Nonmembers	
	Value	Per cent of total value	Value	Per cent of total value
Value and percentage of commodities marketed cooperatively*				
All	$780,546	32.1	$184,850	41.9
South coast	304,959	44.9	60,962	90.4
San Joaquin Valley	141,248	45.5	31,957	52.8
Sacramento Valley	19,329	2.5	1,600	1.5
Bay region	$315,010	85.7	$ 90,331	44.0
Value and percentage of supplies purchased cooperatively				
All	$155,555	33.7	$ 36,332	34.7
South coast	36,559	19.8	11,557	69.3
San Joaquin Valley	18,275	29.8	420	5.8
Sacramento Valley	924	1.8	0	0.0
Bay region	$ 99,797	60.4	$ 24,355	36.4

* Small pools omitted.

Since the percentages of members who marketed and purchased cooperatively were slightly higher than the percentages of nonmembers, and since the values of commodities marketed and of supplies purchased cooperatively were lower, it follows that a greater proportion of members marketed and purchased both independently and cooperatively or that a greater proportion of the large producers of commodities and purchasers of supplies marketed and purchased independently. Inspection of records of interviews shows that both explanations are in order.

It was found that farmers with the greater number of years of experience in cooperative marketing organizations were more likely to be members of general-purpose organizations than farmers with fewer years of experience. While such factors as age of operator may be in-

volved in this explanation, it seems that farmers experienced in c operative marketing do not turn away from general-purpose organiz tions (table 19).

Interest in Public Questions.—Members of general-purpose organiz tions were interested in a greater number of subjects of public impo tance than nonmembers. Taxation, education, and community improv ment led in relative importance as subjects of general interest to me

TABLE 19

YEARS OF EXPERIENCE IN COOPERATIVE MARKETING, OF 440 MEMBERS AND NONMEMBERS OF FARMERS' GENERAL-PURPOSE ORGANIZATIONS, 1931

	Experience in cooperative marketing									
	No experience		1–4 years		5–9 years		10–14 years		15 years or mo	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cen
Members	60	65	54	65	47	68	64	71	76	72
Nonmembers	33	35	29	35	22	32	26	29	29	28

bers. Nonmembers were especially interested in taxation, education, a improved marketing of farm commodities. Other subjects of intere were the tariff, water conservation, the organization of farmers, pe control, power rates, improved marketing, and economics. Members we interested in an average of 1.4 subjects, and nonmembers in 1.1 subjec (table 20).

Use of Service Centers.—Another comparison between members a nonmembers brought out the fact that members of general-purpose o ganizations use more service centers than nonmembers. The service ce ters include trade centers, school, church, and club centers, and medic and legal centers. In order that members of general-purpose organiz tions should not by virtue of this affiliation alone be credited with nu bers of centers which are meeting places for the farm bureau, grange. Farmers' Union, and not centers in any other sense, all count of su open-country centers was omitted unless a school, church, or store w also located at the same place. After this correction had been made, me bers were found to average 3.4 centers and nonmembers 3.0 cente (table 21). Since members operated larger farms, had a larger gr return from the sale of produce, and were affiliated with greater nu bers of other organizations than nonmembers, it was to be expected th they would require the services of a greater number of centers. The needs, especially with respect to farm supplies, implements, etc., we more varied, as were also their organizational connections.

TABLE 20

Questions of Public Importance, 440 Members and Nonmembers of Farmers' General-Purpose Organizations Compared, 1931*

	Totals			Taxation	Education	Community improvements	Tariff
	Farmers	Subjects	Average				
Members	301	418	1.4	84	79	45	33
Nonmembers	139	147	1.1	36	21	5	9

	Water conservation and use	Organization of farmers	Pest control	Power rates	Improved marketing	Economics	Others
Members	29	36	15	20	23	11	36
Nonmembers	12	5	16	12	15	13	12

* Number of subjects in which each farmer was interested ranged from 0 to 5.

TABLE 21

Average Number of Service Centers* per Farm Family for 440 Members and Nonmembers of Farmers' General-Purpose Organizations, by Regions, 1931

Region	All farm families			Member families			Nonmember families		
	Farm families	Service centers	Average per farm family	Farm families	Service centers	Average per farm family	Farm families	Service centers	Average per farm family
Total	440	1,148	3.3	301	1,030	3.4	139	418	3.0
South coast	115	359	3.1	83	266	3.2	32	93	2.9
San Joaquin Valley	124	463	3.7	91	359	3.9	33	104	3.2
Sacramento Valley	84	247	2.9	67	204	3.0	17	43	2.5
Bay region	117	379	3.2	60	201	3.4	57	178	3.1

* The service centers include: post-office, shipping point, grocery center, dry-goods center, banking center, hardware center, implement center; centers for grade school, high school, church, lodge, club, and pictures; dental, medical, and hospital centers; and the legal center.

No one had more than 7 service centers. In a distribution of from 1 to 7, a difference of 0.4 per cent is significant.

STRUCTURAL ORGANIZATION OF THE CALIFORNIA FARM BUREAU

Farm Centers.—While membership of individual farmers is direct in county farm bureaus, which in turn are members of the California Farm Bureau Federation, practically every county farm bureau has its members grouped in local units known as farm centers (fig. 2). Local farm centers do not have separate constitutions and by-laws, their organization and basis of operation being provided for in the constitution and by-laws of the county farm bureaus to which they belong. Practically all of them, however, are informally organized with elected officers and specified times and places of meeting. A few counties have, in place of farm centers, commodity departments which operate in much the same way as farm centers.

It was the definite intention of the founders of the farm bureau in California to stress and emphasize the importance of the rural community as the final unit of organization. The operation of county farm bureaus was definitely and purposely placed in the hands of farmers elected from among their fellow members in each agricultural community of the county. The members themselves thus have full control over the policies of the county farm bureaus.[23] Realizing the prime importance of keeping members interested in and acquainted with the representative and educational functions of their organization, a plan was provided for regular monthly meetings in each local farm center in which the rank and file of the community would participate. Farm-center meetings are usually held in a rural schoolhouse or some other convenient place, although meetings are sometimes held in towns. A few farm centers have built or purchased and equipped meeting places.

These farm-center meetings afford opportunity for the dissemination of information on farm problems and on the activities of the county farm bureaus. They offer a convenient means for farm advisors to reach community groups and to become acquainted with individual farmers, their families, and their farm problems. Furthermore, members are able to make direct contact at center meetings with officers and directors of the state and county farm bureaus and to give expression to their local needs pertaining to agriculture, the farm home, and the community. Such meetings are fundamental in California rural life because they afford opportunity for self-development of individual members

[23] Crocheron, B. H. The function of the farm bureau. California Agr. Exp. Sta. Cir. 209:2–3. 1919.

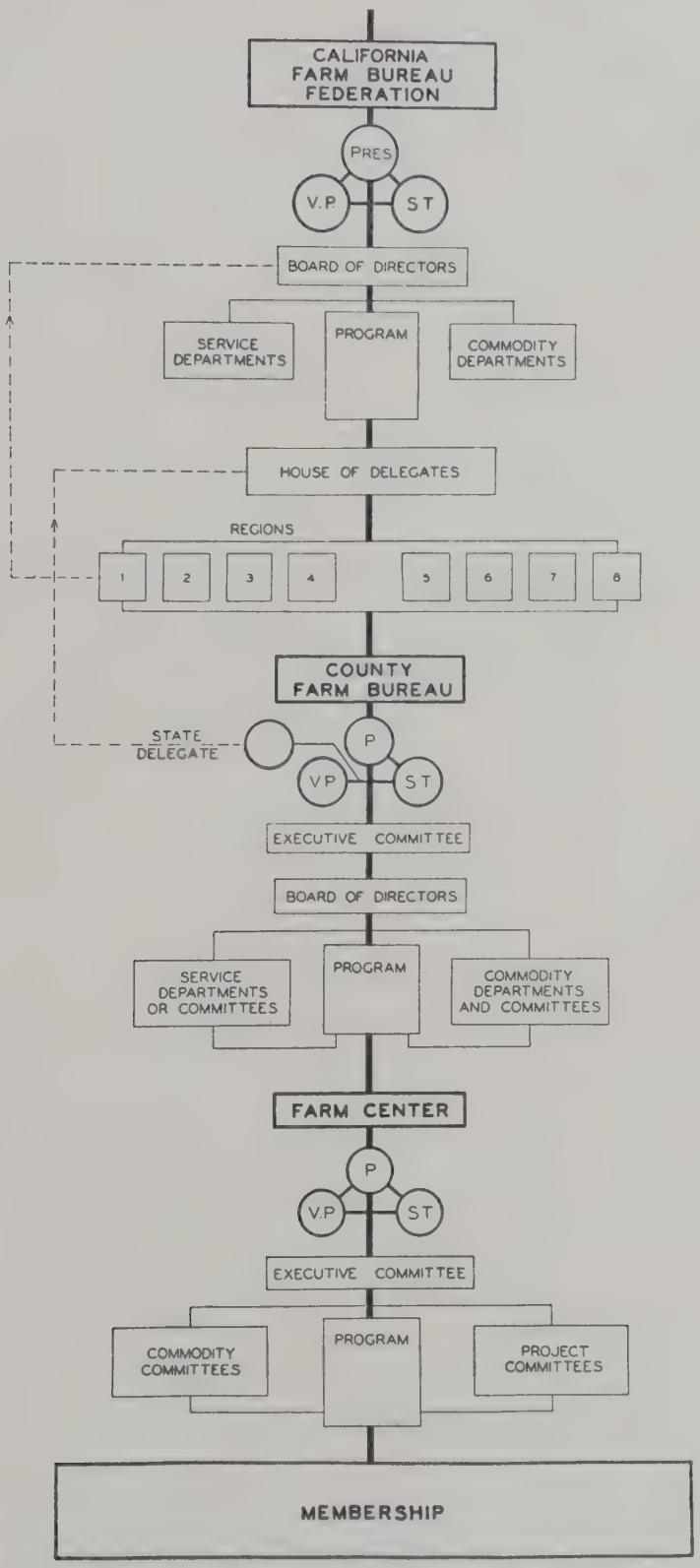


Fig. 2.—Structural organization of the farm bureau in California. Control is placed in the hands of the membership of the local farm centers.

and at the same time training in group activities, year by year, to thousands of farm people. Discussions of economic and social problems, literary and forensic activities, and recreation provided by voluntary effort for all age groups are among the activities carried on by these farm centers.[24]

County Farm Bureaus.—County farm bureaus are formally organized with written constitutions and by-laws. Very few of the county farm bureaus, however, are incorporated. The constitution and by-laws of most county farm bureaus are uniform, each county farm bureau being governed by a board of directors, which is composed of one director from each farm center and a number of directors at large. Farm centers elect their own representative on the county board at a center meeting. Directors at large are usually elected annually at the annual general meeting of members of the county farm bureau. The officers are a president, vice-president, and secretary-treasurer, who are elected by the board of directors annually. In some counties a full-time paid secretary is employed.[25] Board meetings are held regularly, usually once a month, and at that time the board hears reports from the center directors. Thus the county boards of directors not only serve as the governing bodies for the county farm bureaus but they receive and interpret the reports coming directly from the local farm centers. They serve as the integrating body for local sentiment on public questions and as the sponsors of the Agricultural Extension Service in the counties.

All county farm bureaus have several commodity departments such as citrus, dairy, or grain departments, and service departments such as law and utilities, farm home, and membership. A few counties have purchasing departments or committees, but few have cooperative-marketing departments. The number of commodity departments varies from county to county according to local conditions. The service departments, although similar to those of the California Farm Bureau Federation, differ in details of execution and in the variety of application to local situations.

Each individual member is required to pay to the county farm bureau to which he belongs an annual membership fee. In most counties this fee amounts to $5, although in some counties it is higher. Three dollars per member is paid over to the California Farm Bureau Federation

[24] Activities of farm-center meetings were observed by the author during the months of January to June, 1932. Approximately a score of center meetings were attended in Orange, Tulare, Fresno, Stanislaus, San Joaquin, Yolo, and Sonoma counties.

[25] Conferences of farm-bureau secretaries are sometimes held, usually at annual conventions of the California Farm Bureau Federation, for the purpose of exchanging experiences on county-farm-bureau problems and methods of operation.

as state and national dues; the balance is divided between the county farm bureau and the farm center, the basis of division differing between counties.

The California Farm Bureau Federation.—Although the California Farm Bureau Federation was organized in 1919, it was not incorporated until 1931.[26] Its membership consists of the regularly constituted county farm bureaus in California. Article II, Section 2, of the by-laws states that a county farm bureau shall be regarded as regularly organized when it comprises either 50 members or 10 per cent of the farmers in the county, whichever number is the smaller.

Article III, Section 1, provides that the policies and activities of the Federation shall be determined at the annual meeting of its members. These annual meetings serve as a focal point for bringing together the experience and activities of individual counties and officers of the California Farm Bureau Federation during the past year and for formulating policies for the ensuing year. Reports from the various officers and from the directors of the various service departments and commodity departments are received and discussed, new members are admitted, and officers elected. Furthermore, special problems of interest to agriculture are discussed not only from the platform but in selected groups. For example, the director of research led a group of county tax committeemen during the 1931 annual convention in discussions of the results of research in taxation and their practical application in tax reduction.

Each county is represented at the annual meeting by one voting delegate and in addition one nonvoting delegate for each three hundred members or major fraction thereof. All directors, voting and nonvoting, constitute the House of Delegates. This body is empowered to apportion the counties of the various members into eight convenient regional districts, such districts to be composed of counties readily accessible to each other. The state delegates within each region elect one of their number at the annual meeting as a member of the board of directors of the California Farm Bureau Federation. The regional directors hold office for a period of two years, one-half the number retiring annually.

The business and property of the Federation are administered and its policies and activities as outlined by the members are carried out by a board of twelve directors consisting of the president, the vice-president, the State Leader of Farm Advisors, the State Chairman of the Farm Home Department, and the eight regional directors. The officers of the Federation are the president, vice-president, and secretary-treasurer.

[26] Articles of Incorporation were recorded by the Secretary of State, State of California, on October 31, 1931.

The first two officers are elected by the state delegates at the annual meeting in odd-numbered years and hold office for two years. The secretary-treasurer is a full-time official appointed by the board of directors, which also fixes his salary.[27]

The major duties of the executive officers are to interpret the policies of the California Farm Bureau Federation to units within the farm bureau, to legislative bodies, and to other organizations; to carry on from year to year the projects duly authorized; to coordinate the activities of the service departments, commodity departments, and other groups set up by the Federation; and to give emergency service to groups within or without the farm bureau in attacking problems of unusual importance to agriculture.[28]

The officers and directors of the California Farm Bureau Federation carry on their duties in close cooperation with the administration officers of the College of Agriculture. This is desirable because of the close relation between the educational activities of the farm bureau and the Agricultural Extension Service.[29]

Article IX, Section 1, provides for the establishment and maintenance of five service departments—Law and Utilities, Research, Organization, Publicity, and Farm Home. These departments are under the direct supervision of the board of directors of the Federation. The directors of the first four departments are selected by the board of directors of the Federation and serve as full-time employees. The director of the Farm Home Department is elected annually.

Commodity departments may be established by the California Farm Bureau Federation by vote of the delegates at an annual general meeting, or by postal ballot at other times, upon the request of ten or more member county farm bureaus.[30] These departments are made up of delegates from the commodity departments of the county farm bureaus. The chairman of each commodity department is elected annually by the delegates from county commodity departments. He may sit with the board of directors of the Federation and have the privilege of the floor, but he does not have a vote. These departments represent commodities

[27] Five presidents and four secretary-treasurers have held office during the years 1919 to 1932. Two presidents and three secretary-treasurers served during the six years from 1919 to 1925, and three presidents and one secretary-treasurer have held office in the seven years since 1925.

[28] Based on annual addresses of the presidents and annual reports of secretary-treasurers in minutes of annual meetings, especially for the years 1925–1931.

[29] The offices of the California Farm Bureau Federation are located in Giannini Hall, on the campus of the University of California. This building also houses the offices of the Dean of the College of Agriculture, the Agricultural Extension Service, and several other divisions of the College of Agriculture.

[30] By-laws of the California Farm Bureau Federation, Article VII, Sections 1 and 2.

which in the opinion of the county farm bureaus require protection and assistance and are of sufficient importance in California agriculture to command interest in the required number of counties.[31] Committees on cooperative purchasing and on taxation have also been in operation.

The California Farm Bureau Federation is financed by dues received from member county farm bureaus. Each county is required to pay to the Federation $3 for each one of its own paid-up members. Fifty cents per county-farm-bureau member is remitted to the American Farm Bureau Federation, of which the California Farm Bureau Federation is a member. The remainder is apportioned as follows: $1.00 per county-farm-bureau member to the general fund of the Federation, $1.00 to the Law and Utilities Department, and $0.50 to the Research Department.

ACTIVITIES OTHER THAN COMMERCIAL

OBJECTIVES AND FUNCTIONS

The objectives of the farm bureau are the development of rural people and the furtherance of their opportunities for happiness and prosperity. This two-fold statement represents both the educational and the welfare points of view. According to the educational point of view, the farm bureau is an organization of farmers who are combined in order more effectively to secure facts bearing upon problems of their industry. These problems range from soil analysis to prices of farm products. Attainments resulting from the application of facts to problems of production and marketing are to be regarded as means for advancing the social and cultural life of those living in the open country.[32] According to the welfare point of view it is an organization to represent, protect, and advance the social, economic, and educational interests of the farmers of California. While the application of facts to problems is emphasized in connection not only with the educational but also with the welfare point of view, the representative, protective, and promotional functions are central in the latter case.[33]

The activities of the five service departments and the various commodity departments give a fairly complete picture of the activities of the Federation and its objectives and functions.

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[31] Annual report of the Chairman of the Dairy Department. Minutes of the Twelfth Annual Convention of the California Farm Bureau Federation, November, 1930, page 96.

[32] Crocheron, B. H. The function of the farm bureau. California Agr. Exp. Sta. Cir. 209:1–16. 1919. Also: Survey of land grant colleges and universities. U. S. Dept. Int. Office of Education 9(2):442.

[33] Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, 1931. Page 99.

SERVICE DEPARTMENTS

Law and Utilities Department.—The Law and Utilities Department was created at the annual meeting in 1920.[34] It maintains legal, protective, and advisory services for the county farm bureaus and for the individual farm-bureau members. It also maintains engineering services to give advisory service as to technical irrigation and other utility problems. The pioneer achievement of this department was made in connection with the Kern County Farm Bureau and a public utility company in March, 1921. A lowering of rates was secured.

Some examples of the activities and achievements of this department are afforded by presenting extracts from the Annual Report for 1930.[35]

On January 16 the Railroad Commission rendered an interim decision in the .....rate case which has been pending for many months, which reduced the rates of this utility approximately $2,400,000 for the year 1930, and it is intended to reduce the rate of return from approximately 8½ per cent to 7½ per cent. These reductions were made largely to lighting consumers, both urban and suburban. There was also a reduction of about $101,000 in the agricultural-power schedule. Consumers located in the territory formerly served by the..... received the major amount of this reduction, inasmuch as they will in the future be served under the same schedule as the balance of the.....system.

The.....decision was followed on February 4 by a similar decision dealing with the rates on the.....Company, and makes the rates of this utility and the.....Company identical. The total reduction amounts to about $570,000 for the year 1930 and averages about 5⅓ per cent. The agricultural-power reduction is $11,500, the major reduction as in the case of the..... Company being made to lighting consumers.

The issues in this case were the valuation of the property and the extent of the service area. The company desired to include in the service area the so-called..... territory, which is largely owned by....., but is being sold off at the present time. This area already has appropriative and riparian rights in the river aside from any rights it might have to share in the utility service. The inclusion of the.....area appears to have been made dependent upon..... supplying the utility with sufficient power-released water to enable it to properly serve the entire area. This is a proper solution and it is to be hoped that it will become permanent, as it is imperative that the water users under the system should receive water at a later time than would be possible under natural-flow conditions.

In Application 16014 of the.....Company for an increase, an interim decision has been rendered which increases the gross revenue of the company approximately $26,000 per year, according to the Railroad Commission's engineer's estimates. This is very much less than the increase sought by the company.

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[34] Minutes of Annual Meeting of California Farm Bureau Federation directors, November 6, 1920.

[35] The names of the utility companies concerned have been omitted from the quotations.

The company has asked for a complete revaluation of its properties and the establishment of new rates based thereon. It was agreed at the last hearing that work along this line would be conducted later in the year. Consequently this case is still active, although not carried on the calendar. To date, however, the latter request of the company has not been urged.[36]

During the year 1930–31 this department participated in 31 new formal proceedings, in addition to 23 which had been initiated in former years. In the same period, 406 informal cases were received and 323 were closed.[37]

The achievements of this department, in representing the interests of agriculture before the courts and commissions of the State of California, have been made a subject of commendation by a member of the California Railroad Commission. He said:

It is now more than a decade and a half since the regulation and control of public utilities passed from the municipalities to the State Railroad Commission. Generally speaking, the municipalities have not gotten into step with this new order of things. I think it may be said with perfect accuracy that the cities are in this respect ten years behind the farmers of the state, who, through their State Farm Bureau Federation, maintain a special department to represent their interests in matters coming before the commission—a department the value of which to the agricultural group can hardly be overesimated .... I have long felt that the cities should profit by the experience of the Farm Bureau Federation and perfect an organization to look after their interests .... [38]

An examination of the reports of this department during the years of its operation indicates that the benefits of its activities apply to all farmers and, in some cases, to urban and suburban dwellers, and that personal service to individuals in the farm bureau constitute a lesser part of its achievements. Assuming that the point of view of the utilities remains unchanged, the Law and Utilities Department finds that the possibilities for further reductions in power, freight, and other rates are limited.

Practically all county farm bureaus have law and utility service departments. These county departments secure the signatures of farmers in petitions for rate adjustments to be handled for them by the Law and Utilities Department of the California Farm Bureau Federation, investigate complaints about utility companies, sponsor the cases of individuals who have claims against utility companies or commercial concerns, and make preliminary inquiries into irrigation and other utilities prob-

[36] Minutes of the Twelfth Annual Meeting of the California Farm Bureau Federation, November 10–13, 1930. Tenth Annual Report of the Law and Utilities Department. Page 91.

[37] Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, November 16–19, 1931. Page 20.

[38] Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, November 16–19, 1931. Page 20 and following.

lems which call for adjustment or the expert services made available by the California Farm Bureau Federation. They petition local concerns for power-rate adjustments.

The Research Department.—Serious attention to the need for research in farm taxation occupied the attention of the California Farm Bureau Federation at the annual meeting of 1924. Two years later[39] it was announced at the annual meeting of the California Farm Bureau Federation that 29 counties had ratified an amendment to the constitution of the Federation which provided an addition of 50 cents to the annual dues for the support of tax research. The following September[40] a research worker began an investigation of farm taxes and tax legislation. He has been continued in full-time employment since his appointment.

This is one of the least spectacular of the departments operated by the California Farm Bureau Federation. It is, however, accumulating exceedingly valuable files of data on county budgets, income taxes, school taxes, taxes on publicly owned public utilities, and taxes for special purposes. These data are being used in the deliberations of tax committees in county farm bureaus, as well as in the work of research commissions appointed by the state government. The results are better-informed tax committees in the various county farm bureaus, and a growing recognition of farm tax problems on the part of urban and suburban tax bodies.

A brief quotation from a recent annual report to the California Farm Bureau Federation will serve to show the working procedure of this department:

> .... Based upon our research a half score of recommendations were set forth in my [Director of Research] annual report of a year ago. These recommendations were endorsed by you in the form of resolutions and it then became the task of the Department to work for their enactment. Therefore, our time and energies during the past year have been divided between research, the dissemination of information, the popularization of our tax program, and the sponsoring and promoting of tax legislation.[41]

The broad duties of this department are to investigate, to report, and to formulate legislation in connection with agricultural problems, as may be called for, under the direction of the California Farm Bureau Federation.[42]

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[39] Minutes of the Annual Meeting of the California Farm Bureau Federation, November 17–19, 1926.

[40] Report of the Research Department. Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, November 16–19, 1931. Page 17.

[41] From Annual Report of the Director of the Research Department. Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, November, 1931. Page 17.

[42] By-laws, Article IX, Section 5.

The tax committees or departments of county farm bureaus analyze local county budgets for, and make recommendations to, boards of supervisors. They study possibilities for county government reorganization to effect improvements in services rendered and economies in cost. They hear the recommendations and complaints of local tax committees and sift these for suggestions that are sound and workable. They hold tax discussion meetings, secure revaluations of agricultural lands for taxation, and scrutinize local tax expenditures.

The Publicity Department.—The Publicity Department was one of the first to be organized by the California Farm Bureau Federation.[43] With considerable modifications in plans, its work has been carried on largely through the publication of a news organ—the *California Farm Bureau Monthly*. Two paragraphs quoted from the report of this department in 1931 will serve to describe its set-up and activities.

> The set-up and construction of the *California Farm Bureau Monthly* plan of publicity is unique in that each county farm bureau in the state plan receives its own individual magazine. In this way each county farm bureau has an opportunity to share in the make-up and news content of its own individual edition, in whatever way best fits the needs of members in their own respective community. The local appeal and usefulness of the magazine is therefore determined in a large degree by the attention given to this county material . . .
>
> The contents of the state section has, therefore, been devoted principally to the activities of the various offices and departments of the state Federation: namely State Secretary, Law and Utilities, Organization, Research, Home Department, 4-H Club, Dairy, Poultry, Grain Growers, and Deciduous Fruit. A great deal of care and effort is given by the heads of these departments in the preparation of this material and it warrants the attention and thought of every farm-bureau member. Activities of the American Farm Bureau Federation and special articles applicable to conditions in California are included as importance dictates and space permits.[44]

The objective of this department is to make the *Farm Bureau Monthly* in the various counties as effective as possible in promoting the interests of the local county farm bureaus and in promoting their unity and harmony with the California Farm Bureau Federation.[45]

It depends very largely for its support upon the sale of advertising space to business and commercial concerns. This limits its usefulness in the California Farm Bureau Federation and for its readers, and cancels the privilege of free space for farm-bureau materials in other rural papers.

In spite of handicaps, this department has improved the quality of its

[43] The Minutes of the Executive Committee for February 4 and 5, 1921, give a record of arrangements made for the publication of a Farm Bureau Monthly.

[44] Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, November 16–19, 1931. Page 99.

[45] By-laws, Article IX, Section 4.

publication so that its usefulness to students of current problems has become apparent.[46]

The Organization Department.—The first uniform plan of general membership solicitation in the counties was recommended by the California Farm Bureau Federation in October, 1920,[47] and was adopted by many counties during the 1920–21 membership year. The plan included three weeks of publicity in each county, the use of paid county solicitors, the use of hired solicitors in the centers, and the recruiting of volunteer workers to accompany the paid center solicitors. By the following March the plan was reported to be in operation.[48] The reaction to the use of paid solicitors was unfavorable in all counties,[49] however, and a revised plan advocated that all membership work be conducted by center teams of volunteer member workers, supervised by center and county volunteer committees.[50]

In November, 1922, the Federation established an Organization Department, and a State Membership Manager assumed his duties. The major purpose of the Department was to educate county committees in the proper methods of planning a membership campaign, and assisting them to conduct it through a definite time period, using volunteer leaders and workers. Through this adoption by the counties of systematic methods of membership building the California Farm Bureau Federation reached its greatest strength in the following year.

In the summer of 1923, because of unavoidable circumstances, the Department ceased to function, with the result that in ensuing years the counties devoted less time and thought to membership methods and problems. A generally steady decrease in the member strength of the Federation began in 1924 and continued until 1929.

In December, 1929, the Federation recognized that the important activity of membership building was not receiving a balanced attention with other program activities, and the Department was reestablished. With a return of its services and assistance, county membership plans became more definite and systematic, volunteer team effort increased in

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[46] Annual Report of the Director [of the Publicity Department]. Minutes of the Thirteenth Annual Convention of the California Farm Bureau Federation, November, 1931. Page 18.

[47] See mimeographed circular dated October, 1920, filed with the Minutes of the California Farm Bureau Federation for that year.

[48] See Minutes of Board of Directors of the California Farm Bureau Federation, March 18, 19, 1921.

[49] From statements made by W. H. Walker, President of the Federation. Minutes of the Executive Department of the California Farm Bureau Federation, September 8, 1922.

[50] See Minutes of the Executive Department of the California Farm Bureau Federation, July 14, 1922.

the centers, and with the year 1930 the membership strength of the Federation began to increase again.

Every county has a department which is entrusted with organizational and membership work among farmers and their families. A sample county schedule of activities for this department provides for election of all farm-center officers in the county during October of each year, organization of county committees and election of county farm bureau officers in November, organization training school for all center officers in December, special attention to entertainment of guests at center meetings during January, a county-wide play day for all farm centers in February, and, in March, a review training school and discussion of problems for all center officers. These departments cooperate with the Organization Department of the California Farm Bureau Federation in coordinating the work of the county-farm-bureau directors with the organized local farm centers in regard to membership organization and maintenance.

The Farm Home Department.—California's sustained emphasis upon the importance of farm-center activities in the county farm bureaus has kept these organizations close to the farm home. The California Farm Bureau Federation, in cooperation with the home-demonstration section of the Agricultural Extension Service, has rendered direct service to the farm home through its Farm Home Department. Home demonstration extension work is being carried on in more than 300 Farm Home Department centers in 26 counties of the state.[51]

A decided upward trend was shown, during the years 1921–1931, in numbers of registrants, in numbers of nonmembers taking active part, and in numbers of farm homes adopting the practices recommended. Attendance at meetings held by project leaders increased from 1920–21 to 1926–27, then decreased; in 1930–31 it increased to just over 16,000.[52]

The objectives of this department are to assist the farm family to maintain an adequate standard of living by supporting home-demonstration work and by exchanges of experiences in home-making.[53]

The activities of the county farm home departments include supervised school lunches, featuring the use of fruits and of fruit juices as beverages, the study of kitchen arrangement and furniture renovation, rug-making, sewing, jelly-making, the improvement of farm bureau halls, the study of child-rearing, home-grounds planning, and problems of home management.

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[51] Minutes of Thirteenth Annual Convention, California Farm Bureau Federation, February 16–19, 1931. Page 19.

[52] Data obtained from: Home Demonstration Section of the Agricultural Extension Service. Summary of Statistics, 1931.

[53] By-laws, Article IX, Section 2.

The farm home departments of the county and state farm bureaus are built upon a basis of the department centers which carry on their work in conjunction with the local farm centers. They occasionally provide refreshments for the regular meetings of the farm centers and greatly assist with the subject matter for discussion, and in recreational and other group activities.

Other Service Departments.—The 41 county farm bureaus sponsor boys' and girls' agricultural clubs, which totaled in membership approximately 10,000 in 1931. These clubs carry on pig, calf, poultry, garden, field, canning, clothing, and other projects. Several counties are sponsoring recreational camps for 4-H club members and club leaders' conferences. They display exhibits of livestock, fruit, vegetables, and handicrafts, at local, county, and state fairs.

Several county farm bureaus in the San Joaquin Valley and in the counties south of the Sierra Madre Mountains have water committees or departments which cooperate with the county and state water commissions in the study of problems of water conservation, reclamation, and flood control. These departments give attention to taxes, water tolls, and refinancing in irrigation districts. They also formulate plans and policies representative of the needs of their counties and they thus help to mold regional and state water-conservation policies.

Closely related to the work of these departments is the work of various farm bureau fire-prevention committees, which sponsor education in fire-prevention and aid in the organization of fire districts and in the securing of fire-engines and other fire-fighting apparatus for the use of open-country localities.

COMMODITY DEPARTMENTS

All of the county farm bureaus have commodity departments which carry on activities of particular interest to the growers of those commodities. The number and nature of the commodity departments vary from county to county according to the types of commodities produced in each county and to local conditions. The most common commodity departments are dairy, poultry, livestock, grain, and fruits. Similar commodity departments of county farm bureaus are as a rule grouped into regional commodity departments, which meet as often as is deemed necessary to deal with regional problems affecting those commodities. Most of the more common commodity departments of the county farm bureaus are also represented in the commodity departments of the California Farm Bureau Federation.[54] The work of the commodity depart-

[54] Five commodity departments of the California Farm Bureau Federation held meetings at the 1931 annual convention of the Federation. They were the dairy, deciduous fruit, poultry, grain, and sugar-beet growers' departments.

ments of the county farm bureaus is thus coordinated and made effective in a regional or state-wide sense by and through the California Farm Bureau Federation. The activities of commodity departments, county and Federation, are largely protective, promotional, and educational. Control of production, increased efficiency with lower costs of production, improved marketing methods, improved quality, and protective legislation are some of the headings under which specific activities fall. An enumeration of the activities of some of the more important commodity departments will give a fairly concise picture of the objectives of these departments.

Dairy Departments.—In 1931 some 26 county farm bureaus had dairy departments; nearly all these counties were also represented in the Dairy Department of the California Farm Bureau Federation. The county dairy departments in cooperation with the Agricultural Extension Service give aid in the introduction of improved sires, in cow-testing, and other methods of increasing efficiency of production. They also assist in organizing and strengthening dairy cooperative marketing associations. They are watchful of urban regulations affecting the dairy industry and take action against those which appear to work an injustice to the industry. These departments carry on campaigns against butter substitutes and lend support to all efforts to expand local consumption of dairy products.

The dairy department of the California Farm Bureau Federation handles problems of state-wide or even nation-wide interest to dairymen. For instance, the annual report of the Chairman of the Dairy Department at the 1930 Annual Convention of the Federation dealt with the need for identification marks for tuberculosis-tested cattle, both reactors and nonreactors; the need for improvement in the methods of tuberculosis-testing; the need for securing inspection for contagious abortion of all cattle shipped into California for breeding purposes; marketing problems of producers in areas supplying market milk to cities; the encouragement of a uniform type of dairy department in each of the counties; the need of giving attention to the legislation of the state in order that laws affecting the dairy industry may be supported or opposed by the farm bureau as interest may dictate.

Poultry Departments.—Poultry departments of the county farm bureaus sponsor accredited hatcheries, egg-laying contests, and poultry-management demonstrations. They organize producers for poultry disease control. They cooperate with the Agricultural Extension Service in investigations of costs of egg production and with farmers' poultry marketing associations in the improvement of marketing practices. The Poultry Department of the Federation concerns itself with legislation

affecting the poultry industry, uniform egg-grading standards, and other matters of general interest to the industry.

Grain Departments.—Some county-farm-bureau grain departments purchase grain cleaners and dusters which are operated in the local and neighboring counties. Farmers in one county, during one season, treated 10,000 sacks of grain by utilizing the farm-bureau grain cleaner and dusting outfit. Some farm bureaus secure grain demonstration plots in their counties. Pure-seed committees personally inspect and pass upon fields from which certified seeds are offered for sale. Surveys of bulk handling of grain are made. (In California sacks are still widely used for handling grain.) These departments cooperate with the Grain Department of the California Farm Bureau Federation in securing improved marketing facilities for their commodities, and with the Law and Utilities Department in questions affecting freight rates.

The Grain Department of the California Farm Bureau Federation organized a Pure Seed Association in 1925. A recent report of this association lists the names of 44 farmers and farming concerns which are members and specifies the names of farmers and farming concerns to whom certificates have been issued.[55]

Fruit Departments.—Citrus and deciduous fruits offer fairly distinct production and marketing problems. Some fruits such as prunes and peaches require separate departmental organizations because they are largely produced in a few counties. Fruit departments are usually organized by special commodities such as peaches, prunes, apples, and cherries. These departments cooperate with the Agricultural Extension Service in tree-pruning demonstrations and in orchard-management schools dealing with pruning, spraying, pest control, and related subjects. Citrus departments have been watchful of ordinances and measures dealing with smoke nuisances, which sometimes operate to prevent an adequate use of orchard heaters in seasons of low temperature. Some departments organize pools for the purchase of spray materials and fertilizers. They set up committees of growers and packers for the establishment of standard grades for their commodities. Several have fostered studies of the prices of their commodities and of improved marketing methods, and have cooperated in enterprise-efficiency studies.

Grape-growers' departments are active in experiments carried on by research workers in leafhopper control, in the control of other pests, and also in plant disease control. They have also been active in furthering the recent efforts of the Federal Farm Board to stabilize the vineyard industry of the state.

[55] Report of the Pure Seed Association. Minutes of the Twelfth Annual Meeting of the California Farm Bureau Federation, November, 1930. Page 14.

Other Commodity Departments.—Some of the less common county commodity departments provide for the needs of hog, potato, cotton, bulb, hay, and milo-seed producers. They give service as to pure seeds, weights, and marketing conditions. They request surveys for new markets. They give attention to such matters as improved sacking practices on the part of potato growers and the certification of approved seeds. They cooperate in experiments to determine the best fertilizers to be used in the production of a given commodity in a given locality.

COMMERCIAL ACTIVITIES OF THE CALIFORNIA FARM BUREAU

The California farm bureau has been interested in the marketing of farm products and the purchase of farm supplies for a number of years. Interest in group insurance, however, has been of comparatively recent development. The extent and nature of participation in commercial activities by county farm bureaus and by the California Farm Bureau Federation have never been clearly defined nor consistent. There appears to be a belief in some county farm bureaus that commercial activities conducted by and through county farm bureaus will stimulate membership in the farm bureau and at the same time provide a source of revenue supplemetary to or in place of membership dues. It is also contended that large numbers of farm-bureau members who do not belong to established cooperative associations, or who are inadequately served by such associations in the purchasing of farm supplies, would benefit greatly from an expansion of purchasing by the county farm bureaus, especially during the present business depression when any reduction in costs of production is so important. It is the purpose of this section to analyze the past experience of the California farm bureau in commercial activities so as to ascertain whether or not such activities have contributed to the growth of membership in individual counties and what types of commercial activities the farm bureau may safely undertake.

MARKETING AND PURCHASING ACTIVITIES OF THE CALIFORNIA FARM BUREAU FEDERATION

Among the ten committees appointed at the first meeting of the California Farm Bureau Federation in 1919 was one on marketing. Within a few months the question of forming a state-wide marketing organization was being seriously considered.[56] A widespread desire for such an organization led in 1921 to the formation and incorporation of the Cali-

[56] Minutes of Executive Committee of the California Farm Bureau Federation, May 13, 1920.

fornia Farm Bureau Exchange[57] as a subsidiary of the Federation. Its purpose was to act as the selling and buying agency of 21 county-farm-bureau exchanges which were affiliated with it. While the Exchange assisted in the purchase of farm supplies for some county farm bureau exchanges, its major operations were in grain-marketing. The Exchange discontinued active operation in 1924, partly because it had not received the support from members that had been expected and partly because the directors of the Exchange considered that competitive conditions were such during 1924–25, a short-crop year, that members could market their grain to better advantage without the assistance of the Exchange. The following year was also a short-crop year so the Exchange did not function in 1925–26 either. Meanwhile members lost interest in the Exchange and it was not deemed advisable to revive it. The Exchange was finally disincorporated in 1931.

After the California Farm Bureau Exchange was discontinued the attention of the California Farm Bureau Federation was more and more directed toward matters of more general importance in cooperative marketing. Its marketing department, which carried on the functions of the earlier marketing committee, set forth a plan of procedure[58] (1923), which had been made with the advice of economists in the College of Agriculture. The plan included research in connection with questions of marketing and marked the beginning of the California farm bureau's attention to this method of attacking its problems.

An undated statement of policy[59] for the Federation provided that: advice as to organization should be sought from experienced operators and economists; membership should be limited to those producing the commodity to be marketed; organization should not be undertaken until sufficient tonnage is available and is assured for future operations; organization should be along commodity lines; each commodity should be under the control and direction of one general distributing and sales agency; competitive cooperative marketing associations for like commodities should be avoided; market price should be based upon the supply and demand of the particular grade and quality; and management should be honest and efficient and membership loyal. The most important part of this statement of policy was as follows: "The farm bureau will carry forward the study and teaching of farm economics and en-

[57] The operations of the California Farm Bureau Exchange were described in: Knapp, Joseph G. California Farm Bureau Exchange. Harvard Business Review 4 (4):445–457. July, 1926.

[58] Minutes of Executive Committee, California Farm Bureau Federation, January 11, 1923.

[59] Received from a former chairman of the Marketing Department, by letter dated March 11, 1932, to the Secretary-Treasurer of the California Farm Bureau Federation.

courage all cooperative activities tending to improve agricultural conditions. It will gladly assist cooperative marketing in every way it possibly can without the obligations or responsibilities of such organization."

This latter statement represents the present policy of the California Farm Bureau Federation regarding cooperative marketing. The Secretary of the Federation recently wrote:[60] "We are committed to the principles of cooperative marketing and try to serve all commodities .... and we are frequently of assistance to commodity groups by helping them in their organization work." This statement is substantiated by such examples as the work done by the California Farm Bureau Federation in cooperation with the Los Angeles County Farm Bureau in fostering the recent reorganization of the milk producers in that region. While the Marketing Department is not now active as a department, the policies of the Federation are guided by its experience.

About two years ago the California Farm Bureau Federation began to look into the experiences of farmers' organizations with cooperative purchasing, in the East. A committee was appointed during 1931 to head up a discussion of the subject at the annual convention in November of that year. A conference of representatives from 22 counties met during two days of the annual convention and some of the experiences of county farm bureaus in cooperative purchasing were canvassed. This conference favored[61] the purchasing of basic supplies used in the production of farm commodities, the argument being that the farmer is a manufacturer of commodities and is entitled to wholesale prices for basic supplies. It proposed the setting up of a subsidiary form of business organization by the California Farm Bureau Federation. It recommended the establishment of an information bureau to furnish data regarding local and county pools, and other enterprises of the farm bureau. Trade discounts from local merchants and dealers for members only were discussed and advocated.

At the present moment, the policy of the California Farm Bureau Federation regarding the cooperative purchasing of farm supplies is to stimulate research in the subject and to furnish such information as is available to the county farm bureaus and local farm centers.

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[60] Letter to writer dated June 4, 1932, by Alex Johnson, Secretary-Treasurer of the California Farm Bureau Federation.

[61] Report of the Conference on Cooperative Purchasing, Minutes of Thirteenth Annual Convention, California Farm Bureau Federation, November, 1931. Page 98.

MARKETING AND PURCHASING ACTIVITIES OF THE COUNTY FARM BUREAUS

During the years 1917–1919 seven county farm bureaus[62] organized an association known as the California Farm Bureau Hog Marketing Association, with headquarters in Bakersfield. This association is not incorporated. Its purpose is to assemble and grade fat hogs in carload lots to be sold by auction at the place of assembly. Each of the counties represented in this association elects one member of its board of directors. This association is still in existence.

During the years 1919–1924, 21 county farm bureaus formed subsidiary exchanges which were affiliated with the California Farm Bureau Exchange (see page 51). In addition numerous other marketing or purchasing units were set up during the years 1919 to 1932, some as subsidiary associations under the supervision of the county farm bureaus, others as farm-bureau marketing or purchasing departments. As far as can be ascertained, at least 68[63] marketing and purchasing units have operated under the direction of county farm bureaus at some time during the years 1917–1932.

Of these, 22 associations or county farm bureau units are still in existence. Eleven of these associations are engaged in marketing, the remaining 11 in the purchasing of farm supplies. The average existence of the 22 associations in 1932 was 8 years, the range being from 2 to 16 years (table 22).

Seven of the 68 associations, while still in operation as cooperative associations, are no longer under farm-bureau supervision. Two of these associations are engaged in marketing, 5 in the purchasing of farm supplies. The average period of operation of these associations was 7.7 years, of which 4.0 years were under the farm bureau. The range of existence was from 3 to 12 years.

Four of the remaining 39 associations or farm-bureau commercial units were sold to independent interests; 35, including the 21 county-farm-bureau exchanges affiliated with the California Farm Bureau Exchange, have discontinued operation. Several of the 21 exchanges and 9 other associations did both marketing and purchasing; 9 of the associations (not exchanges) did marketing only. Reckoning the years during which the 4 associations sold out as their years of termination, the average period of operation of the 39 associations was only 2.4 years, the range being from a few months to 8 years.

[62] Kern, Kings, Tulare, Fresno, Madera, Merced, and Stanislaus counties.

[63] Counting the seven counties represented in the California Farm Bureau Hog Marketing Association as separate units.

TABLE 22

Marketing and Purchasing Associations or Departments Organized by County Farm Bureaus, 1917–1932

County farm bureau	Name of association	Activity	Year			Volume of business during peak year
			Organized	Of greatest volume of business	Discontinued or separated	
I. Associations operating under the farm bureau in 1932						
Fresno	California Farm Bureau Marketing Association	Marketed fat hogs	1917	1920	.....	$177,000
Kern			1917	1922	.....	300,000
Kings			1917	1919–20	.....	—*
Madera			1917	—*	.....	—
Stanislaus			1917	1919	.....	975,000
Merced			1918	—	.....	—
Tulare†			1919	1927	.....	—
Contra Costa	Contra Costa Farmers' Association	Purchased feeds, grains, coal, sprays	1920	1928	.....	108,225
Tulare	County Farm Bureau Purchasing Department	Purchased gasoline, fertilizer, seeds, sprays	1921	1924	.....	93,700
Sonoma	Farm Bureau Lime-Sulphur Pool	Purchased lime-sulfur solution for spraying	1923	1931	.....	12,960
Contra Costa	Bridgehead Shipping Company	Shipped grapes	1925	1928	.....	66,300
Butte	Farm Bureau Purchasing Department	Purchased covercrop and alfalfa seed	1927	1931	.....	500
San Joaquin	San Joaquin Farmers' Supply Company	Purchased coal, feed, sprays, seeds	1927	1931	.....	6,818‡
Kern	Milo Seed Department of Farm Bureau	Purchased milo seed	1928	1930	.....	300
Tehama	Livestock Shipping Association	Marketed hogs, cattle, lambs	1928	1931	.....	80,000
Butte	Farm Bureau Purchasing Department	Purchased commercial fertilizer	1929	1931	.....	17,600
Kern	Farm Bureau Fertilizer Pool	Purchased commercial fertilizer	1929	1932	.....	24,000
San Luis Obispo	Farm Bureau Livestock Shipping Association	Pooled shipments of livestock	1929	1930	.....	60,000
San Luis Obispo	Farm Bureau Turkey Pool	Pooled turkeys for market	1929	1931	.....	18,000
Fresno	Fresno Farm Bureau Purchasing Department	Purchased sulfur, cyanide	1931	1931	.....	—
Los Angeles	Farm Service Management Company	Purchased fertilizers, gasoline, oils	1931	1931	.....	—§
Sonoma‖	Farm Bureau Purchasing Department	Purchased lead arsenate	1931	1931	.....	$ 3,000

* Dashes indicate that data are not available.

† Sheep, dairy cows, and calves are also marketed in Tulare County.

‡ Incorporated in 1930.

§ Stock company giving patronage dividends.

‖ In 1931, a vetch-seed pool was operated by farm-bureau members, Santa Rosa, the business totaling $699.00; also a kale-seed pool has been operating two years, doing $60.00 worth of business in 1932.

TABLE 22—*(Continued)*

County farm bureau	Name of association	Activity	Year			Volume of business during peak year
			Organized	Of greatest volume of business	Discontinued or separated	
II. Associations operating as independent units						
Santa Cruz	Farmers' Cooperative Exchange	Purchased feeds, farm supplies, hardware	1920	1930	1922	$1,209,828¶
Tulare	Lindsay Cooperative Supply Company	Purchased gasoline, seeds, fertilizers; manufactured spray materials	1922	1928	1931	223,000
Imperial	Imperial Grain Growers, Inc.	Marketed barley, milo, wheat	1923	1929	1925	70,000
Sutter	Farmers' Cooperative Association, Pugsley and Morrison	Purchased farm supplies	1924	1929	1930	250,000
Kern**	Acala Cotton Seed Association	Purchased pure seed	1926	1930	1930	64,000
Santa Barbara	Farm Bureau Exchange	Purchased farm supplies	1926	1926	1928	$ 40,000
Tehama††	Turkey Marketing Association	Marketed turkeys	1929	1931	1930	—
III. Associations sold to independent interests						
Monterey	California Farm Bureau Elevator Corporation (elevator at Salinas)	Marketed grains	1922	1923	1924	—
Monterey	California Farm Bureau Elevator Corporation (elevator at San Lucas)	Marketed grains	1922	1923	1924	—
Placer	California Farm Bureau Elevator Corporation (elevator)	Marketed grains	1922	1923	1924	—
Contra Costa	Lone Tree Shipping Association	Shipped grapes, fruits	1926	1928	1931	—

¶ Physical volume of business was largest in 1931, but in dollars 1930 led by over $150,000.

** Still partly controlled by the farm bureau.

†† No longer limited to farm-bureau members.

TABLE 22—*(Concluded)*

County farm bureau	Name of association	Activity	Year			Volume of business during peak year
			Organized	Of greatest volume of business	Discontinued or separated	
IV. Associations that have been discontinued						
El Dorado	Farm Bureau Exchange	Operated slaughter-house, dehydrator, purchased feeds	1918	1919	1922	—
Glenn	Farm Bureau Exchange	Bought supplies, operated sawmill	1918	—	1922	—
Humboldt	Farm Bureau Exchange	Operated sawmill	1918	1919	1924	—
Mendocino	Farm Bureau Marketing Exchange	Marketed livestock, purchased nursery stock	1919	—	1928	—
Stanislaus, Merced, and Madera	Tri-county Farm Bureau Exchange	Purchased supplies, marketed grains	1920	—	1922	—
Solano	Farm Bureau Exchange	Purchased supplies; sold grain	1920	1923	1928	—
Yolo	Farm Bureau Wool Pool	Marketed wool	1920	1920	1921	—
Yolo	Farm Bureau Marketing Exchange	Marketed fat hogs	1920	1923	1925	—
Farm Bureau Exchanges in 21 counties‡‡	California Farm Bureau Exchange	Purchased supplies, marketed barley, wheat, and oats	1921	1923	1924	—
Monterey	Farm Bureau Exchange	Purchased supplies, sold farm products	1921	—	1922	—
Stanislaus	Tri-county Exchange Elevator at Patterson	Marketed grains	1921	—	1924	—
Stanislaus	Tri-county Exchange Elevator at Montpelier	Marketed grains	1921	—	1924	—
Napa	Farm Bureau Exchange	Purchased feeds, sprays	1922	—	1925	—
Imperial§§	Farm Bureau Purchasing and Marketing Committee	Purchased seeds, feeds; sold cull cows	1927	1927	1928	—
Merced	Merced County Growers, Inc.	Marketed fruits and vegetables	1927	1927	1927	—

‡‡ The California Farm Bureau Exchange began operations in 1921. The county exchanges are estimated to have been organized in 1921, 1922, and 1923. The counties in which the exchanges operated were Alameda, Butte, Contra Costa, Del Norte, Glenn, Imperial, Kings, Kern, Madera, Monterey, Placer, Sacramento, Santa Barbara, Santa Cruz, San Joaquin, San Luis Obispo, Solano, Stanislaus, Tehama, Tulare, and Yolo.

§§ Imperial County Farm Bureau sponsored an Intermediate Credit Bank in 1926, at Imperial, which lasted 6 months and suffered a loss of $75,000.

Source of data:
Information supplied by county-farm-bureau secretaries and county farm advisors, 1932, with the assistance of J. E. Tippett, Assistant County Agent Leader, Agricultural Extension Service.

Distribution of Association by Years.—The number of farm-bureau marketing and purchasing associations or departments increased rapidly from 5 in 1917 to 39 in 1922, and 46 in 1924. While several new associations were formed in 1925, the discontinuance of the 21 county exchanges and a few other associations reduced the number of active associations to only 22 in 1925. By 1931 the number had increased to 30, although several associations had been discontinued during the years 1925 to 1931. In June, 1932, there were only 29 associations, including the 7 associations which had separated from the farm bureau. The greatest number of associations were in operation in the years 1922, 1923, and 1924, during which the California Farm Bureau Exchange was active (fig. 3).

Regional Distribution of Associations.—Marketing and purchasing activities have been more numerous in the San Joaquin Valley than in any other major agricultural region in California. Over one-third of all the associations that were started by county farm bureaus were in the San Joaquin Valley. Half of the associations that are still active are in this region (table 23). County farm bureaus in this region, moreover, have been most active in securing special trade discounts and rebates from local dealers on behalf of their members. This region in 1931 contained about 6,000 of the 21,000 farm-bureau members in California. Next in order of number of associations formed are the Sacramento Valley and Bay regions. The south coast region had only 1 association which is still active. The mountain and central and north coast counties had 20 associations.

Volume of Business.—Information as to the volume of business transacted year by year by each of the 68 marketing and purchasing associations or departments is not in most cases available. Many of the associations have been discontinued and there is no record of the volume of business done by them. In the case of many of the associations still active, data on earlier years of operation are not available. Table 24, however, shows that the volume of business transacted by many of the farm-bureau commercial associations or departments even in the peak years was not very great. It is probable that three associations or groups of associations, the California Farm Bureau Hog Marketing Association, the California Farm Bureau Exchange with its 21 county exchanges, and the Santa Cruz County Farmers' Cooperative Exchange handled in any one year by far the major portion of all business transacted by the various associations or departments connected with county farm bureaus. The trend in volume of business of these three associations can be regarded as furnishing a fairly accurate indication of the trend in the volume of all associations.

The California Farm Bureau Hog Marketing Association handled over $10,500,000 worth of business on behalf of the counties represented in it during the years 1919 to 1931. The California Farm Bureau Ex-

Distribution by Years of Farm Bureau Marketing and Purchasing Associations, 1917–1932

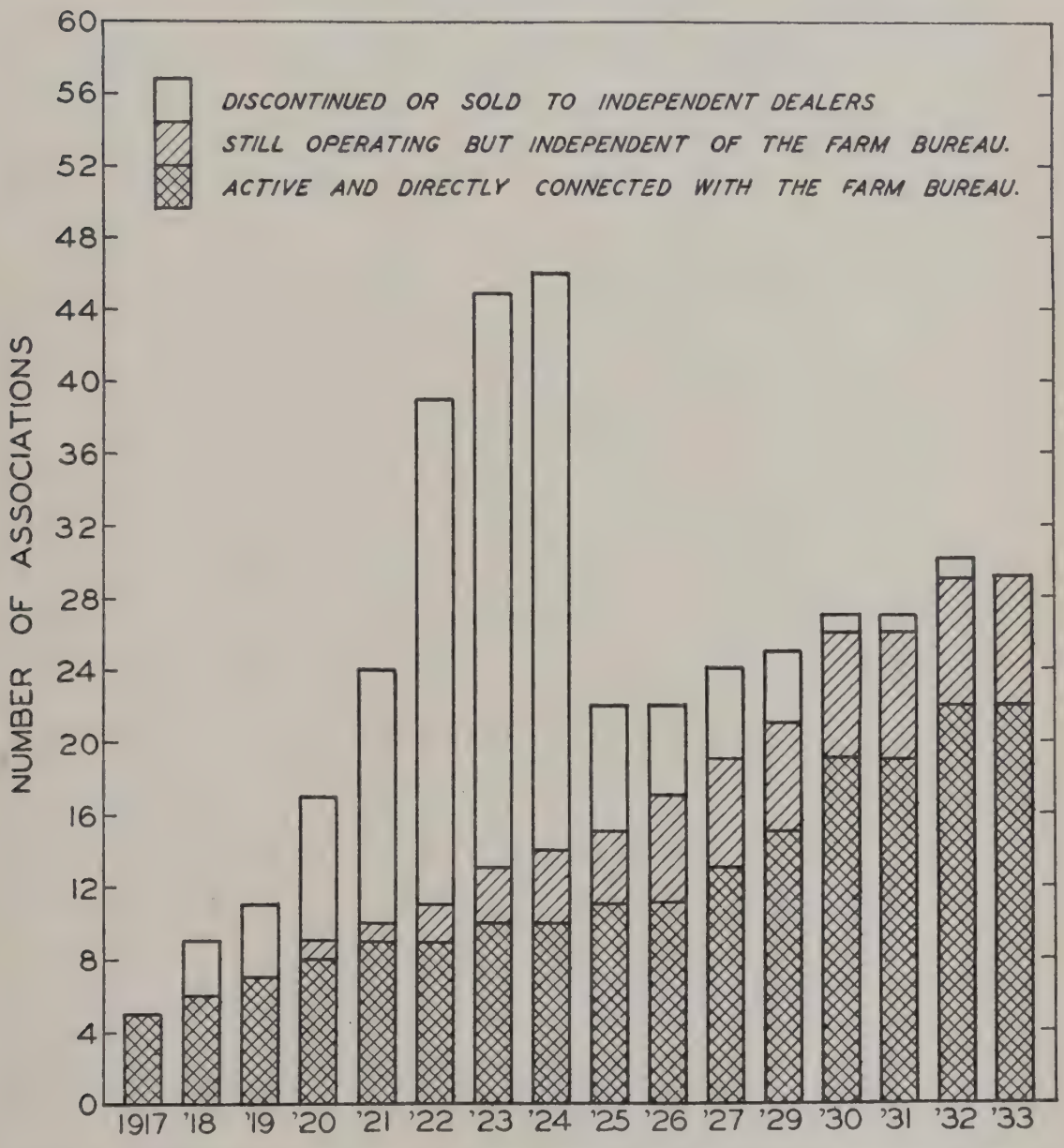


Fig. 3.—Distribution by years of farm-bureau marketing and purchasing associations, 1917–1932. Most buying and purchasing associations were operated during the years 1922, 1923, and 1924. (Data from table 22.)

change marketed grain and purchased supplies to the value of over $7,500,000 during the years 1922, 1923, and 1924.[64] It became inactive towards the end of 1924. The Santa Cruz County Farmers' Cooperative

[64] Estimate based on information supplied by Alex Johnson, Secretary-Treasurer of the California Farm Bureau Federation and formerly Secretary of the California Farm Bureau Exchange.

Exchange handled nearly $7,600,000 worth of farm supplies during the years 1921–1931. The three associations together handled over $10,600,000 worth during the years 1922, 1923, and 1924, or a yearly average of over $3,500,000.[65] Many other associations also did the greatest volume of business during these years. The Yolo County Farm Bureau Marketing Exchange sold $35,000 worth of hogs and the Solano County Farm Bureau Exchange purchased supplies and marketed grain to the value of $100,000 in 1923. In 1924 the Tulare County Farm Bureau's purchasing department handled almost $94,000 worth of farm supplies. Since all three of these associations and many others for whom data are not available were in operation during all three years, 1922, 1923, and 1924, it is probable that the volume of business handled by all farm-bureau commercial departments and associations was in the vicinity of $4,000,000 yearly during the period 1922–1924.

EXPERIENCE OF SELECTED MARKETING AND PURCHASING ASSOCIATIONS

During the three peak years of marketing and purchasing activities certain noticeable changes occurred in center attendance and membership. Center attendance decreased from 199,000 in 1920–21 to 164,000 in 1921–22 and continued to decline during the next few years. Membership increased to 26,000 in 1922–23. The next year, however, membership declined by more than 5,000. The final year of great commercial activity was therefore the year of greatest membership loss and was also marked by a continued decline in center attendance. This seems to indicate some relation between commercial activities and membership. An analysis of the commercial activities of certain selected county farm bureaus and membership furnishes a partial explanation for this relation.

Discontinued Associations.—The El Dorado County Farm Bureau Exchange was organized by the El Dorado County Farm Bureau in 1918 for the purpose of securing improved marketing facilities for the products of its members and to purchase feeds. A slaughter-house and meat-packing plant were operated in one town and a retail meat market and a fruit dehydrator in another. The Exchange had much difficulty in securing suitable managers and by the end of 1921 had employed three different managers. A deficit of over $52,000 had accumulated in the meat-packing plant and the other departments were also operating at a loss. It was decided in 1922 to discontinue operations, and the Exchange

[65] While the Santa Cruz Farmers' Cooperative Exchange separated from the Santa Cruz County Farm Bureau in 1922, it continued to operate in very close contact with the Farm Bureau until about 1924.

TABLE 23

Regional Distribution of Associations

Region	Number of associations				
	All associations formed by county farm bureaus	Active associations in county farm bureaus	Defunct	Associations sold to independent interests	Associations now independent of county farm bureaus
South coast	1	1	....	....	....
San Joaquin Valley	24	12	2	....	10
Sacramento Valley	13	3	2	....	8
Bay region	10	4	....	1	5
Mountain, central and north coast	20	2	3	3	12
Total	68	22	7	4	35

Source of data: Table 22.

TABLE 24

Volume of Business (in Dollars) of Three Associations Organized by County Farm Bureaus, 1919–1931

Years*	California Farm Bureau Hog Marketing Association		California Farm Bureau Exchange	
	Volume of 3-year period	Average yearly volume	Volume of 3-year period	Average yearly volume
	1	*2*	*3*	*4*
1919–1921	$ 3,724,000	$ 1,241,000	.....	.....
1922–1924	2,056,000	685,000	$ 7,600,000	$ 2,533,000
1925–1928	1,778,000	593,000	.....	.....
1929–1931	2,990,000	$ 748,000	.....	.....
Total	$10,548,000	.....	$7,600,000	.....

Years*	Santa Cruz Cooperative Exchange		Combined for three associations	
	Volume of 3-year period	Average yearly volume	Volume of 3-year period	Average yearly volume
	5	*6*	*7*	*8*
1919–1921	$ 105,000†	$ 105,000	$ 3,829,000	$1,276,000
1922–1924	1,007,000	336,000	10,663,000	3,554,000
1925–1928	2,012,000	671,000	3,790,000	1,263,000
1929–1931	4,461,000	$1,115,000	7,451,000	$2,484,000
Total	$7,585,000	.....	$25,733,000	.....

* Fiscal year of California Farm Bureau Hog Marketing Association ended October 31; fiscal years of other two associations December 31.

† One year only, 1921.

Sources of data:

Col. 1: Report by D. H. Bitner, Minutes of the Ninth Annual Meeting of the California Farm Bureau Federation, 1929, page 20; and report by J. J. Nielson, Minutes of the Thirteenth Annual Convention California Farm Bureau Federation, 1931, page 30.

Col. 3: Information supplied by Alex Johnson, Secretary-Treasurer of the California Farm Bureau Federation.

Col. 5: Annual report (1931) of the manager, Mr. J. H. Hauschildt of the Santa Cruz Farmers' Co-operative Exchange.

was sold to independent interests. Since the membership was liable for the debts of the Exchange, the final settlement involved the payment by individual members of $300 and by the county directors of $2,500. The El Dorado County Farm Bureau bore the brunt of the blame for the failure of the Exchange and as a consequence its membership, which in 1921 was estimated to include from 40 to 50 per cent of the farmers in that county, declined appreciably during the next few years.[66]

The Glenn County Farm Bureau Exchange was organized in 1918 for the purpose of purchasing feeds for members. At first the manager was paid on a percentage basis. Economies were effected by assembling orders for feeds, purchasing in large lots, and handling cash business only. The Exchange progressed fairly well until it began to break away from earlier policies. It began to solicit business, extend credit, handle supplies other than feeds, and carry large stocks of supplies in the supposed interests of economy. As a result relatively large sums of money were tied up in inventories. Meanwhile a lumber department had been developed which at first operated a retail lumberyard but very soon purchased and operated a sawmill as well. Disagreement concerning management followed. When prices fell, in 1921 and 1922, the Exchange was caught with large stocks on hand and consequently suffered heavy losses. Liabilities accumulated until in 1922 settlements were forced by creditors. Members and directors were assessed to meet the claims of creditors. Many of these were not paid and law suits followed. The discontent resulting led to a big decline in membership and finally in 1927 the Glenn County Farm Bureau was discontinued. Glenn County is still (1932) without a farm bureau.[67]

The Humboldt County Farm Bureau formed an association in 1918 to purchase feeds. It was intended originally that the association would collect orders for feeds, which when purchased would be distributed to members for cash. The association, however, soon rented a warehouse and employed a manager. During 1919–20 large shipments of feed were ordered in anticipation of a rising market. Large quantities of other farm supplies were also purchased. Credit was extended. The break in prices in 1921–22 found the association with large inventories, which were sold at a considerable loss. The association was forced to cease operating in 1922. Members were assessed to meet the claims of creditors. As in the case of the two previously mentioned exchanges, the discontent

[66] Based on information supplied by Ivan W. Lilley, County Farm Advisor of El Dorado County; C. W. Rubel, Associate Professor of Agricultural Extension; and Alex Johnson, Secretary-Treasurer of the California Farm Bureau Federation.

[67] Based on information supplied by C. W. Rubel, Associate Professor of Agricultural Extension, and Alex Johnson, Secretary-Treasurer of the California Farm Bureau Federation.

resulting led to a loss of interest in the farm bureau and a steady decline in membership until in 1929 the Humboldt County Farm Bureau was discontinued.[68]

The failure of each of the associations operated by the three county farm bureaus may be ascribed partly to poor management, involving overrapid expansion of business, the handling of too wide a variety of products or goods, the carrying of large inventories, and the lavish and unwise extension of credit. The rapid changes in market conditions in 1920 and 1921 called for operation adjustments which were not made in time to prevent heavy losses. Perhaps one of the most important elements in the explanation of the failure of these associations was the fact that they were organized as part of a movement—the farm-bureau movement—and were at first carried forward by the growth of the organization rather than by the merits of efficiency in rendering service and of foresight of the management. As far as can be ascertained the experience of many of the other farm-bureau associations which have failed were similar in many respects to that of the three associations described above.

The failure of these associations appears to have had a direct bearing on and to have been one of the main causes of the decline of membership and center attendance and the difficulty of securing new membership in those counties in which they operated. The farm advisor in El Dorado County made the following significant statement: "While the farm bureau at the present time is not sanctioning any business venture in which the farm bureau, or any of its members are financially liable, the heavy loss incurred in the farm bureau exchange has been a very hard obstacle to overcome in securing new members." All three county farm bureaus mentioned above reached the peak in membership enrollment and center attendance during the years these associations were active. All three experienced a rapid decline after the associations were discontinued. In El Dorado County the decline in center attendance preceded the decline in membership, while in Glenn and Humboldt counties center attendance and membership began declining in the same year (table 25).

Associations No Longer Affiliated with the Farm Bureau.—The success of a farm bureau commercial association does not necessarily involve the success of the county farm bureaus sponsoring them. On the contrary, the success of a commercial association may serve to divert members' interest from the work and activities of the county farm bureaus, the benefits of which are not so clearly discernible. The experi-

[68] Based on information supplied by B. H. Crocheron, Director of Agricultural Extension.

ences of the Santa Cruz County Farm Bureau and the Lindsay Farm Center in Tulare County illustrate this.

In 1920 the Santa Cruz County Farm Bureau organized an exchange, which came to be known later as the Santa Cruz Farmers' Cooperative Exchange, for purchasing poultry feed.[69] A fund for working capital was established by the payment of $5.00 a member. A manager was selected and paid a commission of $3.00 a ton on all feed handled. Unwise buying, both as to quantity and price, soon brought difficulty. Late in

TABLE 25

MEMBERSHIP AND CENTER ATTENDANCE IN SELECTED COUNTY FARM BUREAUS, 1919–20 TO 1930–31

Year	Discontinued associations						Association no longer affiliated with farm bureau		Association still affiliated with farm bureau	
	El Dorado		Glenn		Humboldt		Santa Cruz		Tulare	
	Members	Center attendance	Members	Center attendance	Members	Center attendance	Members	Center attendance	Members	Center attendance
1919–20	160	3,346	367	4,535	200	2,860	161	9,014	706	6,146
1920–21	158	3,196	546	8,298	361	3,102	609	8,471	947	4,782
1921–22	253	1,775	142	7,512	245	2,156	531	5,602	1,441	4,403
1922–23	225	1,103	506	4,710	217	1,535	730	6,175	2,132	5,988
1923–24	174	1,927	363	3,606	163	1,704	537	5,688	1,016	3,260
1924–25	132	3,124	238	3,970	46	1,294	459	5,397	1,983	6,175
1925–26	131	739	244	3,600	194	1,563	506	6,353	1,530	4,509
1926–27	85	1,259	54	1,787	99	1,634	446	5,310	1,473	7,884
1927–28	57	857	53	.....	25	934	335	3,750	1,493	5,964
1928–29	98	547	18	.....	1	35	241	1,720	1,412	7,091
1929–30	73	239	18	.....	.....	.....	431	3,085	1,308	4,433
1930–31	85	2,553	4	.....	.....	.....	300	2,472	1,065	5,468

Sources of data:
Membership from table 3.
Center attendance from: Statistical Summaries, Office of the Agricultural Extension Service, College of Agriculture, Berkeley, California.

the year plans were made for a cooperative organization and in May, 1921, a petition was circulated so as to secure signers favoring the new plans. It was agreed that all signers of the petition must be, or must become, members of the Santa Cruz County Farm Bureau. By the end of the month 208 names had been secured and $2,200 had been collected in membership fees. The fee for membership in the Exchange was $30, $15 of which was to be paid at once and the remainder within six months. A certificate of membership in the Exchange, redeemable at a later date, was issued to each member. While only farm-bureau members were signed up, the fee for the farm bureau was separate from the Exchange fee.

[69] Based on information supplied by: J. H. Hauschildt, Manager of the Farmers' Cooperative Exchange; and H. L. Washburn, Farm Advisor for Santa Cruz County.

Modest and careful purchasing, cash payment and cash collections, together with unfailing care as to details of management, resulted in satisfactory growth. At first a small rented building was used, then a small warehouse was purchased; a building in the county seat was leased, and the volume of sales rapidly increased. Bran which had retailed for $40 a ton was handled at $28 after allowing a small margin to be refunded to members later. Corn, bran, shorts, middlings, and mixed feeds were ordered from the mills of the Middle West because of the advantage over Pacific Coast prices for these supplies.

The Exchange increased in members from 221 in 1921 to 1,226 in 1931, and in volume of business from $104,952 in 1921 to $1,042,896 in 1931. The range of supplies now includes poultry feeds, hay and other feeds, gasoline, oil, hardware, and miscellaneous supplies. The services of cracking, grinding, and cleaning grain have been added to the services of purchasing and mixing feeds. The Exchange owns a mill and a large store and warehouse. Another store and warehouse are leased.

Difficulties began to arise soon after the formation of the Santa Cruz Farmers' Cooperative Exchange as to membership dues in the Exchange and the county farm bureau. Dues in the Exchange were paid only once, upon a member's joining, and thereafter a member could continue to participate in the commercial activities of the Exchange; dues in the county farm bureau, however, were payable annually and involved membership participation of a very different nature from the business relations of a cooperative association. Furthermore, many members had joined the county farm bureau on the strength of its promises, implied or explicit, to correct certain marketing and purchasing evils. With the improvement in conditions members began to lose interest in the farm bureau. Many members who had formerly paid their farm-bureau dues regularly, now neglected or refused to continue payment. They were not interested, they said, in supporting two organizations to get the benefit of one.

It seemed clear to the leaders of the Exchange that a number of farmers had joined the farm bureau in order to obtain the services offered by the Exchange and that having achieved this they were no longer interested in the farm bureau. Two organizations could not be supported on one set of merits; each had to stand on its own merits. Farmers interested in securing one type of service could not be compelled to continue in another association offering another type of service which they did not greatly desire. As farm-bureau dues were not collected from a number of farmers, who were members of the Exchange, it was decided finally that the Exchange would accept new members without requiring membership in the Santa Cruz County Farm Bureau.

Towards the end of 1922 it was decided that the Santa Cruz Farmers' Cooperative Exchange would be formally separated from the Santa Cruz County Farm Bureau. Another factor which hastened formal separation was the mistaken criticism of local dealers that the Agricultural Extension Service, through the local county farm advisor, was in business. Actually, however, the separation took place gradually and was not generally recognized for several years. The Santa Cruz County Farm Bureau continued to report the operations of the Exchange to the Annual Convention of the California Farm Bureau until 1925.

Membership and center attendance in the Santa Cruz County Farm Bureau did not increase as rapidly as membership in the Exchange during the period the two organizations were closely identified. The Exchange has experienced a steady growth in membership since it was organized, the growth continuing after it was separated from the county farm bureau. Beginning with 1923–24, however, membership and center attendance in the county farm bureau decreased more or less steadily up to 1930–31 (table 25). While the success of the Exchange may not have been the only factor which influenced the decline in membership of the Santa Cruz County Farm Bureau, it is probable that the successful operation of a commercial organization does lessen members' interests in the intangible and long-time benefits and services of the farm bureau in the face of the immediate and visible benefits derived from membership in the commercial organization.

The experience in Santa Cruz County seems to have been more or less duplicated in Tulare County, except that in the latter instance the commercial association was formed by a farm center and not by the Tulare County Farm Bureau, and operated on a local rather than a county-wide basis. In 1922 the members of the Lindsay Farm Center organized a commercial association for the purpose of mixing lime-sulfur for spraying citrus groves. Savings thus effected attracted growers from as far as 20 miles away, although the association was a farm-center affair, promoted by the members of the Lindsay Farm Center. In 1923, owing to the demands of the members of the lime-sulfur association, the Lindsay Farm Center also organized a fertilizer pool. These two associations soon began to handle other types of supplies, including gasoline, oil, tires, paint, and farm machinery. As the volume of business increased the Board of Directors began to meet separately from the Board of the Lindsay Farm Center, although reports were made regularly to the farm center. The two associations were combined in 1927 into the Lindsay Farm Center Supply Company, an independent incorporated cooperative association. Although it was intended originally that the services of the two associations and later of the Supply Company would

be confined strictly to members of the farm bureau, many members of the Supply Company have failed to keep up their dues in the farm bureau. Moreover, the Supply Company accepts new members who are not farm-bureau members. In 1931 less than 60 per cent of the members of the Supply Company were paid-up members of the farm bureau.

Active Farm-Bureau Associations.—It cannot be said that county-farm-bureau commercial associations which have been successful and which have been maintained as an integral part of the county farm bureau have been successful in sustaining membership in the farm bureau. It is possible, of course, that such commercial activities may have prevented a decline in membership, although there is little evidence to support such a conclusion.

Of the 22 marketing and purchasing associations which are still operating in county farm bureaus, 11 are engaged in the marketing of farm products. Seven of these associations constituting the California Farm Bureau Hog Marketing Association have had a long and on the whole fairly successful career. The other four associations are relatively small. There appears to be little direct relation between the operations of this association and farm-bureau membership in the counties in which it operates.

There are 11 purchasing associations, the oldest and largest of which are the Tulare County Farm Bureau Purchasing Department and the Contra Costa Farmers' Association. A brief survey is given below of the operations of the first-named association as an illustration of the operations of purchasing associations still connected with the farm bureau.

The Tulare County Farm Bureau Purchasing Department was organized in 1921. During the next three years it purchased on behalf of members 212 cars of grape stakes and 143 tons of wire and also small quantities of other types of supplies. About 1924 the types of supplies handled underwent some change, sulfur, trays, spray materials, seed, and box shook (for fruit-box construction) being the principal types purchased. The volume of business handled by the purchasing department declined from $90,000 in 1924 to about $42,000 in 1931, largely because of loss of business to the Lindsay Farm Center Supply Company above referred to. In 1931 the principal types of supplies handled were gasoline and oil, seed, sulfur, fertilizer, and trays. The purchasing department of the Tulare County Farm Bureau also arranges for workmen's compensation insurance at reduced rates and negotiates whenever possible special trade-discount agreements with local merchants on behalf of members. A small charge is made by the purchasing department above costs of handling so that a purchasing fund of several thousands of dollars has been accumulated. The purchasing department is man-

aged without cost to the department by the full-time paid secretary of the Tulare County Farm Bureau.[70] Careful management, cash business, and service to members have been characteristic of this association.

Tulare County Farm Bureau has maintained a fully paid-up membership of 1,000 or more. The peak of membership was reached in 1922–23 (table 25). The next year membership declined almost 50 per cent, to be followed in 1924–25 by a big increase almost to the 1921–22 level. Since 1924–25 membership has declined more or less steadily. Center attendance has fluctuated considerably from 3,260 in 1923–24 to 7,884 in 1926–27. There is little positive relation between membership and center attendance. The instability of center attendance seems to indicate an element of weakness in this phase of the structure of the Tulare County Farm Bureau.

The experience of the Tulare County Farm Bureau in commercial activities does not seem to indicate any very definite relation, one way or the other, between farm-bureau membership or center attendance and commercial activities. Several other counties which have not engaged actively in marketing and purchasing have sustained and even increased their membership. On the other hand, a few of these counties have like Tulare County experienced a decline in membership during recent years. All that can be said is that farm-bureau marketing and purchasing associations do not necessarily guarantee sustained or increasing membership even in counties in which these associations are successful.

TRADE DISCOUNTS AND REBATES

Another type of commercial activity carried on by many county farm bureaus instead of or in addition to the marketing of farm products and the purchasing of farm supplies is that of obtaining on behalf of members special trade discounts or rebates from local dealers or merchants.

County Farm Bureaus and Trade Discounts.—Trade discounts for members have been negotiated for many years by county farm bureaus. As early as 1921 the Tulare County Farm Bureau had secured trade discounts for members from local dealers on seeds, box shook, and grape stakes. In 1924 the San Diego County Farm Bureau negotiated a 10 per cent discount on retail prices of farm implements and obtained wholesale prices for members on lime, sulfur, dusting materials, and grape stakes. The next year it arranged in addition for a 10 per cent discount on retail prices of automobile tires. The Santa Barbara County Farm Bureau secured in the same year a discount of 1 cent a gallon below

[70] Based on information supplied by Mr. Allen Thompson, Secretary of the Tulare County Farm Bureau, in a letter dated June 9, 1932.

regular farm-delivery prices on gasoline and kerosene and various discounts on oils and greases. By 1929, 7 counties were regularly securing discounts for members on various supplies from local dealers and merchants. In February, 1929, this activity had extended to 28 different counties,[71] several of which were also operating purchasing associations or departments. The types of supplies on which discounts were obtained and the amount of discounts on particular types of supplies varied from county to county and sometimes even within a county. Gasoline, oils, greases, tires, automobile parts, lumber, spray material, fertilizer, feeds, seeds, paints, and hardware were some of the more common supplies purchased in this way (table 26).

The Economic Significance of Trade Discounts.—There are some very significant differences between this type of commercial activity and that of purchasing supplies through county farm bureau subsidiary associations or supply departments. Under the latter form of commercial activity the association or purchasing department contracts for the purchase of supplies and assumes financial responsibility towards the agents from whom it buys. The purchasing body must in most instances have some working capital, especially if it extends credit to members. If its business is at all large one or more full-time persons must be employed. As the terms which such associations or supply departments can obtain from individual agents depend largely upon the size of orders placed with them, there is always the incentive for the association or supply department to make its operations attractive to members through the granting of credit, special services, and carrying stocks of goods. Unless extreme caution is used, such services are likely to lead to serious financial losses. Furthermore, as these purchasing units of county farm bureaus frequently purchase supplies from wholesale dealers or manufacturers, they enter into direct competition with local dealers and merchants, whose volume of business is decreased in proportion to the increase in volume of these purchasing units. Such a state of affairs is likely to build up antagonism to all the work of county farm bureaus from business houses within localities in each county.

Under a system of trade discounts, on the other hand, the county farm bureau merely undertakes to use its influence with members to purchase certain types of supplies from local dealers (or merchants) in consideration of the latter's conceding members special agreed-upon discounts on particular supplies below prevailing prices paid by nonmembers.

[71] These counties were Alameda, Butte, Colusa, Contra Costa, El Dorado, Fresno, Kern, Kings, Lake, Lassen, Marin, Merced, Modoc, Napa, Nevada, Placer, Sacramento, San Diego, San Joaquin, San Luis Obispo, Santa Barbara, Solano, Sonoma, Stanislaus, Tehama, Tulare, Yolo, and Yuba.

TABLE 26

TRADE DISCOUNTS FOR MEMBERS OF COUNTY FARM BUREAUS, BY SELECTED COUNTIES AND BY SUPPLIES PURCHASED, CALIFORNIA, 1932

County *	Name of company contracting	Supplies on which discounts are given	Amount of discount			Year contract was made‡
			Per cent†	Flat discount		
				Amount	Unit	
A	3 oil companies	Oils and greases	20	.....	.....	1931
B	1 milling company	Feeds	15	.....	.....	1931
	1 oil company	Lubricating oils	20	.....	.....	1931
	1 garage	Tires	10, 7	.....	.....	1931
		Auto repairing	30	.....	.....	1931
C	3 supply stores	Sulfur	.....	25–50c	cwt.	1931
		Calcium cyanide	.....	$2.00	cwt.	1931
	4 oil compaines	Oils	.....	10–15c	gal.	1931
		Greases	.....	10–15c	lb.	1931
	1 tire company	Tires and accessories	10,10,2	.....	.....	1931
	1 auto supply company	Auto parts and accessories	5, 10	.....	.....	1931
D	2 oil companies	Oils, Greases	.....	13c	gal.	1932
E	3 oil companies	Oils, Greases	—	.....	.....	1931
	1 tire company	Tires and tubes	5	.....	.....	1928
		Batteries	25			
	1 paint company	Paints, wall paper	10, 40	.....	.....	1931
	1 tire company	Batteries, tires, and tubes	10, 10, 10	.....	.....	1930
	1 rubber company	All rubber goods	10	.....	.....	1929
F	2 tire companies	Tires	19	.....	.....	1930
	1 oil company	Lubricating oils	10	.....	.....	.....
	1 tire company	Batteries	10	.....	.....	1932
	1 auto-supply company	Auto parts, accessories	10, 30	.....	.....	1927
	7 lumber yards	Varnishes	20	.....	.....	.....
		Paints		50c	gal.	1928
	1 piping company	Pipe, tanks, and pumps	5, 20	.....	.....	1929
	1 nursery company	Nursery stock	10	.....	.....	1930
	1 brake service company	Greasing, wheel alignment, brake adjustment, and repairs	20	.....	.....	1930
	1 repair works	On all repairs	10	.....	.....	1930
	1 fruit company	Spray materials		Dealer's price plus 5 per cent for handling	.....	1931
	1 laboratory	Chicken-pox vaccine	33⅓	.....	.....	1931
G	7 lumberyards	Monarch paints	18, 20	.....	.....	1931
	1 auto-supply company	Auto accessories and batteries	.....	Wholesale	.....	1931
	1 tire company	Tires, tubes, batteries	10	.....	.....	1931
	1 supply company	Spray materials	5	.....	.....	1932
	1 oil company	Oils and greases	15, 43	.....	.....	1932
	1 seed company	Seeds	15	.....	.....	1932
	1 refinery company	Smudge oil	.....	.....	.....	1932
H	1 oil company	Gas	.....	1c	gal.	1928
		Oil	.....	.....	.....	
	1 supply company	Miscellaneous supplies, sulfur and sprays	.....	Wholesale	.....	1928
	1 seed company	Seeds	.....	Wholesale	.....	1921
	1 sulfur company	Sulfur	.....	Dealer	.....	1925
	1 auto-supply company	Auto accessories	.....	Dealer	.....	1925
	1 lime company	Lime	.....	Dealer	.....	1927
	1 chemical company	Sulfate of ammonia	.....	Jobber	.....	1930
	1 manufacturing company	Spray rigs and parts	.....	Dealer	.....	1928
	1 supply company	Oil sprays	.....	Jobber	.....	1928
	1 spray chemical company	Sprays	.....	Jobber	.....	1928
	2 fertilizer companies	Fertilizers	.....	Jobber	.....	1929, 1930

* County designated by letter instead of by name in order to avoid disclosing trade information.

† Each separate number represents a different type of discount, e.g., trade discount and cash discount.

‡ Some contracts are made from year to year, others are for an indefinite period, while in practice they all may be cancelled upon giving notice, usually 30 days in advance.

Source of data:

Information supplied by county farm bureau secretaries and county farm advisors, with the assistance of J. E. Tippett, Assistant Leader of Farm Advisors, Agricultural Extension Service.

Under such conditions the county farm bureau assumes no financial responsibility towards the local dealers; each individual member contracts directly with the dealer for the supplies he requires. The increase in business accruing to a merchant from a concentration of member purchases enables the dealer to effect certain economies and a reduction in unit operating expenses, part of which he can afford to pass on to members in the form of a discount.

It is probable, moreover, that certain additional discount advantages may be derived by members by reducing the amount of service required of dealers. For instance, if members could order machinery and other types of supplies through a dealer but take delivery directly from a manufacturer or wholesale agent at the railroad, the dealer could afford to quote a lower price because he would be saved the expense of carrying the supply in stock and handling it.

While possibly some opposition may be directed towards the county farm bureau from dealers who are not successful in obtaining the contract to supply members, the opposition is likely to be much less severe than when county farm bureaus enter into direct competition with local dealers. Moreover, this type of commercial activity consumes much less of the time of the officials of the county farm bureau and reduces the danger of subordinating other and more important activities to commercial activities. Members derive a direct and tangible benefit from belonging to the county farm bureau, a benefit that would not accrue to them if they were nonmembers. The obtaining of special discounts from local dealers is a form of service which it would seem county farm bureaus are justified in undertaking if members desire it and provided care is exercised to ensure that this form of activity is kept in balance with other and possibly more important activities.

It is necessary to point out, however, that there are certain limitations to the benefits which can be derived by members from collective bargaining for trade discounts through local dealers. There are more or less definite limits to the size of discount which a local firm could afford to allow members. The savings effected would not, except under unusually favorable conditions, be as great as members could obtain by buying from a cooperative association which purchased supplies. Moreover, there would be a tendency for firms excluded from such an agreement to reduce their prices to a point at which the successful firm or firms would have to reduce their discounts. This would lead to an all-around reduction in prices on particular items of supplies, which would benefit nonmembers as well as members.

Furthermore, it is necessary for county farm bureaus to exercise great care in selecting the type of supplies on which discounts are sought and

the dealers from whom the supplies are bought. Quality as well as price is of importance. It is conceivable that a county farm bureau may succeed in getting a special discount on oil and gasoline but that a low-quality product may be supplied. Moreover, there is a temptation for dealers to grant the same discount privileges to nonmembers in order to increase their volume of business still further. If this is done, much of the buying advantage supposedly derived by individual farmers from membership in a county farm bureau is lost. It is thus important for each county farm bureau to assure itself that the dealer with whom it enters into a contract to supply members at a discount confines this advantage to members only. One very important weakness of the discount method is that farmers knowing what discount they can obtain from a particular dealer with whom an agreement has been made will use this information to get other dealers to give them a still greater discount. If this happens to any extent in a particular locality it is likely to weaken the bargaining power of the county farm bureau and also to cause the dealer with whom the contract was made to become dissatisfied.

TABLE 27

AVERAGE POTENTIAL NUMBER OF CUSTOMERS PER DEALER FOR ONE COMMODITY AMONG NONMEMBERS AND MEMBERS OF SIX COUNTY FARM BUREAUS

County	Number of farmers in county (1930)	Number of farm-bureau members (1931)	Non-members in county	Number of dealers handling commodity in county	Number of dealers with whom discount agreements were made	Average potential customers per dealer		
						Non-members	Members	
							All firms in county	Only one firm in county
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Butte	2,603	501	2,102	5	5	420	100	501
Colusa	894	289	605	4	4	151	72	289
Kings	2,156	380	1,776	4	4	444	95	380
Tehama	1,805	405	1,440	4	4	350	101	405
San Joaquin	5,730	2,331	3,399	5	1	679	.....	2,331
Stanislaus	5,743	517	5,226	5	1	1,045	.....	517

Sources of data:
Cols. 1 and 2: Table 3.
Col. 3: Figures in col. 1 less figures in col. 2.
Cols. 4 and 5: Information supplied by county farm bureau secretaries.
Col. 6: Col. 3 divided by col. 5.
Col. 7: Col. 2 divided by col. 5.
Col. 8: Col. 2.

In order to secure the greatest possible discount on any particular supply, it is necessary that the county farm bureau contain a considerable number of members, that the item selected be one which is generally used by large numbers of members, and that agreements be made with only one dealer in each trade area. Agreements with more than one

dealer in a given trade area for discounts on a supply such as gasoline, tires, or grape stakes, divides the volume of business and weakens the farm bureau's bargaining power. Several county farm bureaus appear not to have realized this (table 27).

The mistake of dividing the volume of business between two or more dealers is illustrated in the case of the first four counties in table 27. In these four counties the nonmembers offer a more attractive potential business than members. This is true because all dealers offering discounts could expect to serve only a part of the farm-bureau membership, averaging from 72 customers per dealer in Colusa County to 101 in Tehama County. On the other hand, nonmembers averaged 151 potential customers per dealer in Colusa County and 444 in Kings County. If each county farm bureau had contracted with only one firm, however, the potential customers per dealer would have averaged 289 in Colusa County and 501 in Butte County.

In contrast, San Joaquin and Tehama counties have consistently followed the practice of making agreements for each type of supply with only one dealer, thereby offering an appreciably larger number of potential customers. San Joaquin was in a stronger bargaining position than any of the other counties because of its large membership, which was over four times as great as the next highest county membership.

Rebates for Members.—A few counties instead of arranging with dealers for trade discounts to members on their purchases are arranging for these firms to make rebates to the farm bureau, the amounts, of course, depending on the volume of business transacted by members with these firms. The Stanislaus County Farm Bureau introduced a system of rebates as trade-discount agreements made in 1931 terminated. In order to operate more efficiently, its purchasing committee was enlarged and reorganized into a purchasing department which includes among its members a purchasing representative from each farm center in the county. A purchasing agent was elected, who is responsible for making contracts, for the clerical operation of the department, keeping records, and disbursing rebates to the members. Contracts were in operation in 1932 with firms which handle oils, gasoline, smudge oil, automobile tires and tubes, spray materials, and other farm supplies.[72] The financial plan is briefly described in a circular as follows:

> In Stanislaus County the Purchasing Department receives 15 per cent on an annual saving of $20,000, 14 per cent on $30,000, 13 per cent on $40,000, 12 per cent on $50,000, and 11 per cent on $60,000. These percentage amounts are $3,000, $4,200, $5,200, $6,000, and $6,600, which are paid to the Purchasing Agent, who in turn pays

[72] Information supplied by C. L. Seagraves, Jr., Purchasing Agent for the Stanislaus County Farm Bureau.

out of this money the Department has earned, all the expenses of the Purchasing Department, pays back any money borrowed from the County Farm Bureau, and what is left is his salary. Stanislaus County is set up on a calendar quarterly rebate basis. The reason for this is that rebating the membership oftener is too costly, yet we do not want to hold the members' refunds any longer than is necessary. The rebates from the firms with which we have contracts are also based on the calendar quarter.

Advantages and Disadvantages of the Rebate System.—This system is a variation of the trade-discount system and appears to have some advantages over it. Established prices are not disturbed. Prices paid by members at the time of delivery are the same as prices paid by nonmembers, and refunds or discounts are made at a later date. Actual refunds of cash are likely, moreover, to be more tangible evidence of service. As in the case of trade discounts, however, competing dealers may offer members and nonmembers special price advantages or discounts which may force the contracting dealers to reduce their prices and eventually their rebates. This is likely to be the case especially if the number of members of the farm bureau is small as compared with the number of nonmembers. If the amount of rebates is reduced there is always the danger that poorly informed members may lay the blame upon the purchasing department of the farm bureau instead of taking account of the adjustments which have taken place in competitive conditions. Under conditions of business stress members are likely to take advantage of cash discounts offered by competing firms rather than wait for rebates even if the eventual savings may be greater. Nevertheless, negotiation of rebates, as in the case of discounts, would seem to offer a form of service which county farm bureaus could undertake with advantage if the members desire such service.

INSURANCE

Among the types of insurance service in which the farm bureau has at one time or another been interested are fire, automobile, life and accident, and workmen's compensation insurance.

Fire Insurance.—As early as 1925 the California Farm Bureau Federation was interesting itself in insurance. Attention at that time was centered largely on fire insurance, especially on the benefits of county mutual insurance companies. A joint committee on rural fire insurance reported that the mutual companies offered a satisfactory insurance for farmers and that, with certain suggestions for improvement, the farm bureau should endorse them.[73]

[73] Minutes of the Executive Committee of the California Farm Bureau Federation, June 18 and 19, and September 30, 1925.

Automobile Insurance.—In 1927, the farm bureau also became actively interested in automobile insurance. So urgent a demand for this type of service had come from certain counties that the California Farm Bureau Federation made it a matter of special investigation. In January, 1928, the executive committee sent notices to the various counties requesting them not to sign agreements with any automobile insurance company until the state Farm Bureau Federation had completed its inquiries and made recommendations.[74] As a result of its deliberations the Executive Committee of the California Farm Bureau Federation recommended in February, 1928,[75] that county farm bureaus place all automobile insurance through the State Farm Mutual Automobile Insurance Company of Bloomington, Illinois, which was to be officially represented in the state by the California Farm Bureau Federation. The Secretary-Treasurer of the Federation was made state insurance director for the automobile insurance company and in each of the eight regions (see page 39) of the California Farm Bureau Federation the regional agency was delegated to be the regional director.[76]

By August, 1928, the Los Angeles County Farm Bureau had an agent in the field. By the middle of November, 39 counties had adopted the insurance plan, 26 counties were organized, and 197 agents had been appointed.[77] Three thousand policies were reported in effect by the middle of January, 1929. For the fiscal year November 1, 1928, to October 31, 1929, a total of 16,345 policies were written. The year 1930 began vigorously.[78] By early May, 3,552 applications were reported as compared with 2,872 for the corresponding period of the previous year.[79]

But dissatisfaction expressed by certain counties with an arrangement whereby the farm bureau was affiliated with a commercial concern led in midsummer to a reconsideration of policy on the part of the California Farm Bureau Executive Committee. By unanimous vote it decided that it was advisable to cancel the existing contract between the California Farm Bureau Federation and the automobile insurance company.[80] Termination was effected on January 31, 1931. While the state

[74] Minutes of the Executive Committee of the California Farm Bureau Federation, January 20 and 21, 1928.

[75] Minutes of the Executive Committee of the California Farm Bureau Federation, February 9, 1928.

[76] Minutes of the Insurance Committee of the California Farm Bureau Federation, March 23 and 24, 1928.

[77] Minutes of Tenth Annual Meeting, California Farm Bureau Federation, November, 1928.

[78] Minutes of Activities Conference of the California Farm Bureau Federation. March 3, 1930.

[79] Minutes of the Executive Committee of the California Farm Bureau Federation. May 6, 7, and 8, 1930.

[80] Minutes of the Executive Committee of the California Farm Bureau Federation, July 19, 1930.

Federation no longer represents this insurance concern, it recommends it to those applying for automobile insurance.[81]

According to this insurance plan farmer-owned automobiles are classified as preferred risks. Two discounts are made, one in the form of lowered premiums to farmers and the other in the form of refunds to the county farm bureaus of the counties in which business is done. Since all automobile owners are solicited, the special advantage to the members of the farm bureau comes in the form of refunds to their organization based on the volume of business done in new policies and in policy renewals in their county.

While a great number of county farm bureaus are under agreement with this automobile insurance company, some counties have worked out plans with other companies. One county,[82] for example, made an agreement in 1928 with an insurance company which had done business in the county for over twenty years to write automobile insurance for members of the farm bureau and grant them a discount of 15 per cent below regular charges. Approximately 1,000 members took advantage of this offer during the year. The following year, a discount of 18 per cent was allowed, and in 1930 this was raised to 20 per cent. This agreement is still in force (1932). According to this plan all of the discount is made directly to the policy-holder, and these terms are open to members of the farm bureau only.

Life Insurance.—Life insurance for farm-bureau members had been under consideration by the California Farm Bureau Federation for some time. Finally, in May, 1930, the executive committee voted not to take further steps on the question. The Butte County Farm Bureau has made arrangements for preferential rates on life and accident for members.[83]

Workmen's Compensation Insurance.—Workmen's compensation insurance has also commanded the attention of the farm bureau. In a recent report (1930) on this subject the Secretary-Treasurer of the California Farm Bureau Federation included a blanket policy which had been prepared with the assistance of the State Compensation Insurance Fund.[84] Two years earlier the Los Angeles County Farm Bureau worked

[81] The California Farm Bureau Federation early made provision for a referendum to the county farm bureaus on matters which involved changes in policy or departures from usual lines of activity. But even when a majority approved of a measure, a determined minority could not be ignored without damaging the organization.

[82] Harvey Van Vlear, Executive Secretary of the San Joaquin County Farm Bureau.

[83] Ray Wiser, Vice-President of the California Farm Bureau Federation, 1931–32, by letter dated March 26, 1932.

[84] Minutes of the Executive Committee of the California Farm Bureau Federation, August 28, 1930.

out a blanket policy for employers of farm labor with an insurance concern which handled this kind of insurance.[85] While this agreement resulted in savings to members it was canceled after a year of operation owing to changes in the management and policy of the insurance company. A similar arrangement was made with another company and refunds amounting to 25 per cent of the premium were made in 1931. The San Joaquin County Farm Bureau[86] secured with the same company a minimum rate plus refunds on actual experience within the county. In both counties these agreements have resulted in improvements in methods of handling help, particularly with regard to the use of machinery and implements. The extension of this type of service to a considerable number of counties has been largely due to local initiative.[87]

Membership Significance of Insurance Activities.—By far the greatest amount of insurance business has been done in automobile insurance. The state Federation promoted this activity during the years 1928–29 and 1929–30. It will be recalled that during 1928–29 membership in the farm bureau reached the lowest point in its history. This cannot be attributed to any one cause, but lack of balance among the activities of the California Farm Bureau Federation during these years must be reckoned as a contributing factor in the decline of membership.

The experience of the California farm bureau in insurance activities has not been of sufficient duration to permit of any definite conclusions as to the desirability of this form of activity as a part of the permanent program of the farm bureau. It would appear that both the Federation and the county farm bureaus may with advantage to their organization undertake to represent their membership in the negotiation of especially favorable rates for members with established insurance companies, whose standing the farm bureau has previously investigated. The position of the farm bureau with regard to these companies would be similar to that of county farm bureaus to local dealers. It would seem inadvisable for either the Federation or county farm bureaus to identify themselves too closely with any particular insurance company or to undertake to organize insurance business themselves. It would be better for each county farm bureau to restrict itself to merely arranging favorable rates for members with insurance companies and recommending to their members that they support these companies. Care must be exer-

[85] Earl Maharg, Secretary of the Los Angeles County Farm Bureau. Agreemeent was with Pacific Employers.

[86] Harvey Van Vlear, Executive Secretary of the San Joaquin County Farm Bureau.

[87] Among other county farm bureaus which have made use of this type of service are Butte, Colusa, Lake, Marin, Monterey, Riverside, San Luis Obispo, Solano, Sutter, Tulare, and Yolo.

cised, moreover, that this form of activity does not consume too much time of the officials of the Federation or county farm bureaus and that other activities, which may be just as important, are not neglected as a consequence.

If the special benefits of agreements with insurance companies go directly to members and if the rates constitute a considerable saving over those paid by nonmembers, the advantage in regard to building up farm-bureau membership seems clear. But if the benefits offered are available to all farmers alike and refunds are made to the county farm bureau, the advantage to members would not be so clear. The support of a county farm bureau in any other way than by direct contribution of its members may be a source of weakness and even of embarrassment. Financial dependence upon dues collected from members tends to stimulate activities which reflect the interest of the members.

EVALUATION OF FARM-BUREAU OBJECTIVES AND ACTIVITIES

The foregoing analysis of the structure, objectives, and activities of the California farm bureau serves to show that it is a general-purpose rather than a special-purpose organization. The grange and the Farmers' Union belong to the same class of farmers' organizations. Among the best known and most important types of special-purpose farmers' organizations are those set up to market particular types of farm products cooperatively or to purchase farm supplies collectively. The farm bureau differs from these special-purpose organizations in structure, objectives, and activities.

Special-Purpose Organizations.—Cooperative marketing associations owned and operated by farmer members are organized to assemble, grade, pack, store, ship, finance, and distribute particular commodities in order to effect savings in the cost of performing these services and to pass the services so effected back to members. They also aim at promoting the consumption of the product or products handled by them by means of advertising and consumer education. Cooperative marketing associations usually restrict their operations to one particular commodity such as cotton or tobacco or to a group of related products such as poultry and eggs, citrus fruits, or deciduous fruits. Such associations may and often do organize departments or subsidiary associations for the purpose of purchasing supplies required in the processing and marketing of the commodities handled by them or used by members in the production of those commodities. Groups of farmers often form cooperative associations for the specific purpose of collectively purchasing

farm supplies required by them. The primary objective of these cooperative associations is to increase the net financial returns obtained by members. They may and often do carry on educational and membership work and interest themselves in legislative matters[88] affecting the commodity they handle or their members, but this work is largely supplementary and incidental to their purely commercial operations.

General-Purpose Organizations.—General-purpose organizations like the farm bureau, the grange, and the Farmers' Union are set up to promote the welfare and education of all their members. Such organizations have such large objectives and carry on such a wide range of activities that they are continually faced with the problem of maintaining balance among their activities. Commercial enterprises often divert the attention of members from the ultimate and contributing objectives of the organization. This easily leads to overemphasis of commercial activities with a resulting lack of balance among all activities. Some other activities may from time to time be overemphasized; but restoration of balance has proved, in the case of the farm bureau, to be exceedingly difficult in instances where commercial activities have been overemphasized.

Furthermore, since the California farm bureau includes in its membership producers of nearly all agricultural commodities, it would be difficult for the farm bureau to make its services equally available to all members by engaging in cooperative marketing without setting up and operating a large number of commodity cooperatives. This, of course, would be most undesirable, for such associations would undoubtedly come into conflict with established cooperative associations handling practically every type of agricultural commodity produced in California. Any duplication of the services performed by these associations would not be to the benefit of California agriculture. The past experience of the farm bureau in California in operating cooperative marketing associations has not been such as to warrant confidence in this type of activity in the future. The California Farm Bureau Federation has done no cooperative marketing since 1924. The 11 farm-bureau marketing associations described above are operated by county farm bureaus to serve local needs. It is probable that these needs could be as well served by cooperative associations which have no official connection with the farm bureau.

The California farm bureau at present (1932), however, is not so much concerned with the development of cooperative marketing associa-

[88] The major cooperative associations in California have formed a permanent legislative committee with headquarters at Sacramento. The Executive Secretary of this committee is Mr. Ralph Taylor.

tions as with the development of a policy regarding the collective purchasing of farm supplies for members. It seems to be the belief that if collective purchasing could be delegated to a subsidiary organization such commercial activities would not conflict to any extent with the more general objectives and activities of the farm bureau. In substance the recommendations of the Cooperative Purchasing Committee at the 1931 annual convention of the California Farm Bureau Federation were that a subsidiary association be organized to purchase for farm-bureau members the basic supplies used in the production of farm products. The problem is not whether it is advantageous for farmers to purchase basic supplies cooperatively in order to lower production costs but whether it would be advantageous for the farm bureau to operate a subsidiary purchasing association.

The Significance of Subsidiary Economic Associations.—It may be as well to analyze briefly the purpose of subsidiary associations and how closely such associations are identified with the parent associations. A subsidiary organization is generally set up to perform a function for which provision has not been made in the structure of the parent organization. It is also a device to isolate the legal obligations of two or more sets of commercial or other operations from each other. If the one organization fails the other may still operate. There are no legal objections to the organization of subsidiaries in order to expand the functional operations of a parent association. From an economic viewpoint, a subsidiary association, although a separate legal entity, is justified if it is needed to perform a function or functions which, together with those of its parent organization, serve to complete an economic unit of organization. For instance, the purchasing subsidiary of a cooperative marketing association not only serves to isolate the financial obligations involved in performing the function of purchasing from those involved in carrying on the function of marketing, but also serves to expand and round out the services performed by the parent association on behalf of its members. In this case the functions performed by the parent and the subsidiary associations may be said to be homogeneous and supplementary.[89]

Weakness of a Farm-Bureau Subsidiary Purchasing Association.—Subsidiaries set up by a general organization, such as the farm bureau, in order to market farm commodities or purchase farm supplies, introduce functions which the organization was not primarily organized to

[89] For example, the California Fruit Growers' Exchange of Los Angeles, originally formed to market citrus fruits, organized a subsidiary, The Fruit Growers' Supply Company of Los Angeles, to purchase or manufacture the packing materials and other supplies needed in marketing the citrus fruits handled by the associations affiliated with the California Fruit Growers' Exchange.

perform. To plan a subsidiary in order to do cooperative purchasing is not logically the same procedure for the farm bureau as for an association which was primarily set up to perform a direct economic function. This has been illustrated in the cases of the purchasing associations which separated from county farm bureaus because it became impossible for the county farm bureaus to collect dues from members whose main interest was in the services performed by the purchasing associations (pages 63–67). The successful performance of the economic function of the purchasing associations did not directly depend upon the performance of the functions of the farm bureau. Subsidiaries used by general organizations to perform direct economic functions therefore introduce heterogeneous functions.

Just as the subsidiary of a cooperative association is identified with the parent association in the mind of the average man, so the subsidiary of a general organization is identified with the general organization. This creates no difficulties in the case of the cooperative association since the subsidiary assists in carrying out the special purpose of the parent association; by means of the subsidiary the usefulness of the parent association is increased and the loyalty of members strengthened. In the case of the general-purpose organization, the specific purpose of an economic subsidiary for a number of reasons tends to confuse the members. Officers of the organization may and often do spend a disproportionate time with the affairs of the subsidiary. For example, the officers of the California Farm Bureau Federation spent an unusual amount of time during the years 1921–1924 with the business of the California Farm Bureau Exchange. During 1923, while yet in the midst of marketing operations, the state Federation found it advisable to turn its attention more to matters of wider application in marketing rather than to devote so much time to one particular organization.[90] Because of this and other reasons (page 52) the marketing subsidiary was discontinued during the following year.

Members are confused, moreover, because of the difference in their relation to the parent and subsidiary organizations. The customer relation between a member and the subsidiary is not the same as the relation between a member and the general organization. This tends to divert loyalty from the general organization if the member is satisfied with the services of the subsidiary, or to undermine loyalty if he is not satisfied or if the subsidiary fails. The history of farm bureaus from which subsidiary associations have separated or with which associations

[90] Report of J. A. Teagarden, Chairman of the Marketing Department. Minutes of the Executive Department of the California Farm Bureau Federation, January 11, 1923.

have failed, illustrates this difficulty. Another factor that tends to confuse members is the difference in the methods of support of the subsidiary and the general organization. A subsidiary economic association is supported out of the savings effected in the performance of its functions. A general organization, however, such as the farm bureau, is supported by dues periodically collected. Support of the subsidiary is considerably more compulsory and direct in nature than support of the general organization and thus superficially seems more easy to command.

In view of all these difficulties it does not seem advisable for the California farm bureau to organize a subsidiary purchasing association, more especially since purchasing facilities are already available through cooperative marketing associations to which many farm-bureau members belong. An extension of purchasing facilities by the California Farm Bureau Federation or county farm bureaus may tend to weaken the established cooperative associations and to antagonize them.

The Problem of Membership Maintenance.—As membership in the California farm bureau is of a distinctly voluntary nature, this organization is continually confronted with instability and discontinuity in membership. This situation is difficult to avoid since many kinds of services are demanded of the organization and they are rendered with varying degrees of success. Furthermore, many of the special functions and activities of the farm bureau are often overlooked by members. Fluctuations in numbers of members not only affect all activities but directly influence the financial support of the organization, especially when it is solely dependent upon dues.

It is this difficulty of maintaining membership which has led many county farm bureaus to interest themselves in cooperative purchasing and other specialized commercial activities. It was felt that the direct savings which could be effected by members would stimulate their interest in the farm bureau and promote support of that organization. The past experience of the farm bureau, however, has shown that commercial activities do not give any definite assurance of membership support; on the contrary, both successful and unsuccessful commercial operations have in many instances resulted in decreased support.

As far as can be ascertained, the surest way for county farm bureaus to maintain membership interest and support is to maintain a wide range of activities of a useful nature vigorously carried on and at the same time to maintain a balance in these activities. This point is illustrated by the experience of the San Joaquin County Farm Bureau (page 18) and several other county farm bureaus. In passing from a membership position of comparative weakness to the command of nearly 40 per cent of the farmers in the county, the San Joaquin County Farm

Bureau has carried on a full program of departmental activities and has emphasized farm-center meetings. This county farm bureau has made liberal use of trade-discount agreements with local merchants as a service to members and as an attraction to nonmembers. It is not engaged in the operation of marketing and purchasing associations, although one of its farm centers has developed a cooperative purchasing association. In none of these things is this county unique. Other counties have carried on corresponding activities but with no such great increase in membership. Few counties, however, have carried on so full a round of activities with as great a degree of balance among them, and no county has succeeded in placing so large a proportion of young farmers[91] in office and in leadership in the organization. The combination of well-balanced activities, a capable full-time secretary, an efficient agricultural extension staff, and vigorous young leaders, has produced exceptional results.

Many county farm bureaus need not aim at enrolling the majority of farmers in each county. Relatively large memberships are unwieldy and difficult to unify on matters of general policy and practically impossible to mobilize on questions of immediate importance. The proportion of farmers to be aimed at as a goal for membership would be governed by the experience of the organization in securing unity regarding policies on questions of general importance and by the number of farmers in the county. Thus small counties may enroll larger proportions of farmers.

The Problem of Balance of Activities.—It would seem, therefore, that it is of vital importance to county farm bureaus and the California Farm Bureau Federation to give constant and increasing attention to the problem of maintaining a proper balance of activities. It is suggested that the following guiding principles will be of value as a basis for maintaining balance among activities:

1. That both ultimate and contributing objectives be frequently brought to the attention of officers and members of the organization.

2. That proportional attention be directed toward meeting both immediate and long-time needs of farm people, with immediate needs subordinated to those which are more general and enduring except in case of practically unanimous demands.

3. That all activities be fundamentally related to the attainment of the objectives of the organization.

4. That no activities be undertaken which cannot be advantageously carried on within the normal organization structure, except those which

[91] Based on estimates made by the farm-bureau secretaries and farm advisors as to the ages of all county-farm-bureau directors in California. San Joaquin County Farm Bureau was the only one in the state whose board of directors contained men who were under 40 years of age, to the extent of 50 per cent or more. In the farm bureaus as a whole 75 per cent of the county directors were 40 or older.

would facilitate the attainment of objectives. These, only, justify a change in structure.

5. That changes in activities and in structure, when decided upon, be primarily related to changes in long-time policy. Careful policy-making is essential to the maintenance of balance among activities and to the proper functioning of all parts of the organization.

Commercial Activities and Balance of Activities.—The question naturally arises as to what part commercial activities can play in the program of the California farm bureau. Is it desirable that the farm bureau dissociate itself from all commercial activities, or have particular types of commercial activities a rightful place in the program of the farm bureau? It is safe to say that it is undesirable for either the county farm bureaus or the California Farm Bureau Federation to undertake the operation of cooperative marketing or purchasing associations except under extraordinary circumstances. The negotiation of trade-discount and rebate agreements with local merchants and special insurance rates with well-established insurance companies may be undertaken with advantage by county farm bureaus provided members demand these services, that these activities do not require a disproportionate amount of time of county farm bureau officials, and that the trade-discount and rebate activities do not conflict with the operations of the established cooperative associations. General educational work among members relative to the importance and economic significance of cooperative marketing would appear to be in line with the educational objectives of the farm bureau. It is also desirable that the farm bureau stand ready at any time to assist particular groups of farmers to organize cooperative marketing associations or to render service that may be of value in strengthening particular cooperative associations. Another desirable function along commercial lines seems to be in the field of legislation. While many of the cooperative associations in California are affiliated with and maintain a Legislative Committee, it would appear that legislative representation for farmers in California should go beyond the activities of the present Legislative Committee.[92] Not only is this true with regard to the interests of farmers as an occupational group, but in connection with legislation of wide application in the commonwealth, farmers need representation as citizens as well as representation as producers of farm commodities.

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[92] Ralph Taylor, Executive Secretary of the Legislative Committee of the Cooperative Associations, Sacramento, California, set forth in substance the view that California farmers need legislative representation in a larger sense than as producers of certain commodities, May 3, 1932.

MEMBERSHIP VIEWS ON FARM-BUREAU FUNCTIONS

Classification of Views on Farm-Bureau Functions.—It is interesting to learn how closely the views of members coincide with the conclusions arrived at above relative to farm-bureau functions. Among the 440 farmers interviewed during the course of this study were 270 farm-bureau members (page 24). Of these, 159 gave definite statements as to what they considered were the chief functions of the farm bureau. Many of the farmers mentioned two or more functions, resulting in a total of 199 statements on functions. These 199 statements on functions were divided into two major groups, the one group stressing educational, legislative, social, and general functions and the other marketing and purchasing functions. These statements were further subdivided on a regional basis so as to ascertain the views of members in different regions on farm-bureau functions. One hundred and thirteen statements stressed educational, legislative, social, and other general functions, 79 marketing and purchasing functions, 6 other functions, and 1 statement indicated that the farm bureau had no function. In all four regions more members stressed general functions than marketing and purchasing functions, although the San Joaquin Valley region showed more members stressing marketing and purchasing functions than any other region (table 28).

TABLE 28

Statements of Members on Farm-Bureau Functions

Region	Total statements		Statements stressing							
			Educational, legislative, social and general assistance functions		Marketing and purchasing functions		Other functions		No functions	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
All	199	100	113	57	79	40	6	3	1	....
South coast	47	100	24	51	18	38	4	9	1	2
San Joaquin Valley	85	100	43	51	41	48	1	1	....	....
Sacramento Valley	43	100	28	65	14	33	1	2	....	....
Bay region	24	100	18	67	6	33	....	....	....	....

Sample Statements by Individual Members as to Farm-Bureau Functions.—A few of the statements made by individual members serve to

indicate somewhat more clearly the views of members as to the functions of the California farm bureau.

Farmer A (south coast region): "The farm bureau has done much for farmers in legislative and educational work. It brings to the farmer economic information regarding his industry, informs him as to the probable effects of proposed legislation, and aids him in understanding market conditions. Its farm-center work satisfies the social needs of farm people."

Farmer B (Sacramento Valley): "Wife and family are active in the Farm Home Department and in 4-H Club work of the local farm center. The farm center is the only unifying organization for local farm families and its social and educational work fills a great need."

Farmer C (Sacramento Valley): "As a protective and promotional organization the farm bureau serves as the farmers' 'watch-dog.' It informs him as to dangers in proposed legislative measures and forwards his interests by fostering measures favorable to agriculture."

Farmer D (San Joaquin Valley): "The farm bureau is primarily a fact-finding and fact-disseminating organization. As such it serves the farmer with respect to production, marketing, and legislative problems."

Farmer E (Bay region): "Since the farmers' greatest need is for education and self-development the farm bureau's educational function is by far the most important. Its greatest achievements have been in interesting the farmer in self-education and in furnishing subject matter for the solution of his problems."

Farmer F (south coast region): "The farm bureau has been valuable in connection with water conservation, in lowering utility charges, and in furnishing information on taxation. It has helped the farmer to attack these major problems intelligently."

Farmer G (south coast region): "In addition to its legislative and research work the farm bureau should set up a subsidiary to purchase farm supplies such as fertilizers and feeds and operate as a marketing agency for all of the state taking care of commodities not handled by commodity cooperatives. It should bring pressure to bear upon the Federal Land Banks to provide farm loans at lower rates."

Farmer H (south coast region): "The best service of the farm bureau is given through the law and utilities and research departments. Cooperative purchasing of farm supplies on a county and farm center basis should be carried on."

Farmer I (San Joaquin Valley): "Interest in taxation, production efficiency, and the tariff have been aroused by the farm bureau. Some of its most valuable work is done through farm-center activities. Farm women have much to gain from the work of the Farm Home Department. The farm bureau should limit its purchasing of farm supplies to the county unit as to size."

Farmer J (Bay region): "The farm bureau is an all-round farmers' organization especially useful to assist in controlling utility rates, in tax reform and giving general assistance to cooperatives. It should not operate any business concerns."[93]

Views Relative to Marketing and Purchasing by the Farm Bureau.—Of the 270 farm-bureau members interviewed, 222 gave an opinion as to whether or not the California farm bureau should engage in marketing

[93] Compare with: Manny, F. B., and R. C. Smith. The Ohio Farm Bureau Federation from the farmers' viewpoint. U. S. Dept. Agr. Bur. Agr. Econ. in cooperation with Ohio State University, Dept. of Rural Econ. and the Federal Farm Board. Page 89, table 48. (Mimeo.)

and purchasing: 110 members were opposed to the farm bureau's engaging in these activities, 101 members were in favor, and 11 qualified their statements so that it was difficult to ascertain whether they were in favor or opposed. The San Joaquin Valley region is the only region in which the majority of members are in favor of the farm bureau's engaging in marketing and purchasing activities. In each of the other three regions members were definitely opposed to the farm bureau's engaging in this activity (table 29).

TABLE 29

Farm-Bureau Members in Favor of or Opposed to the Farm Bureau's Engaging in Marketing and Purchasing

Region	Total		In favor		Opposed		Neutral	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
All	222	100	101	45	110	50	11	5
South coast	64	100	22	34	35	55	7	11
San Joaquin Valley	76	100	53	70	21	28	2	2
Sacramento Valley	60	100	22	37	36	60	2	3
Bay region	22	100	4	18	18	82	..	....

Some of the members who were in favor or were opposed to marketing and purchasing activities by the farm bureau gave their reasons for their views. Those who were in favor considered that the purchasing departments of many of the cooperative associations do not make sufficient savings for members on their purchasing operations; that the commodity marketing associations handle only a few of the commodities produced by California farmers; and that farm-bureau purchasing departments could serve producers who do not have commodity marketing associations. Those who were opposed considered that the farm bureau should not operate enterprises which enter into competition with cooperative associations already in existence; that the farm bureau was intended to serve as a unifying factor in community and county and that interest in specific commodities for sale and supplies to be purchased is not sufficiently far-reaching to serve this end; that the close identification of the farm bureau with the Agricultural Extension Service in the minds of many people makes it inadvisable for the farm bureau to enter the field of competitive business; that the farm bureau was not set up primarily to perform functions of marketing and purchasing.

The figures and statements appearing in this section indicate that while many members are in favor of the farm bureau's engaging in marketing and purchasing activities (mainly the latter), most members do not consider that these are desirable functions for it.

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BERKELEY, CALIFORNIA

Bacteriosis (Blight) of the English Walnut in California and Its Control

B. A. RUDOLPH



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Bacteriosis (Blight) of the English Walnut in California and Its Control[1]

B. A. RUDOLPH[2]

INTRODUCTION

The present paper is concerned primarily with results obtained in spraying experiments for the control of bacteriosis (blight)[3] of the English walnut that have been conducted on a large scale at widely separated points in California since 1927.

Walnut bacteriosis is not a new disease. In relation to the history of walnut culture in California it may be considered rather an old one. Between the time when bacteriosis was first observed over forty years ago and the present, much important information about it has been obtained and published. For the sake of clarity, however, as well as to make the control data presented herein easier reading for the grower for whom this paper was written or for the plant pathologist who may never have made a study of the disease, a digest of the known basic facts concerning it has been prepared.

It is not in the matter of laboratory studies of the organism that research has lagged but rather in the matter of control. The control of parasitic disease in plants lies chiefly along two lines: the development of immune or highly resistant varieties, and the use of preventive sprays or treatments. Although considerable effort has been expended, no immune or even highly resistant variety of English walnut has been found to date. Some so-called "blight-resistant" varieties have been announced from time to time in the past, but none has measured up to the expectations. Their apparent resistance seemingly depends not upon any inherent physiological properties of the trees but, rather, merely upon the extent to which their new growth escapes rain in the spring as the result of late foliation. The Eureka variety, once acclaimed as highly resistant and even immune to bacteriosis in southern California, is now known to be very susceptible there in occasional years when late spring rains pre-

[1] Received for publication November 23, 1932.

[2] Associate Plant Pathologist in the Experiment Station.

[3] While the term "bacteriosis" is far more descriptive and definitive than "blight," it is not wholly satisfactory. Crown gall, a bacterial disease of walnuts, is technically a case of true bacteriosis also. As used throughout this paper the term "bacteriosis" refers exclusively to the disease commonly called "walnut blight," "black spot," "black plague" (peste negra), etc., and caused by the attack of the bacterial organism originally named *Pseudomonas juglandis* by Pierce.

vail. In the damper San Francisco Bay region this variety may be attacked severely, and in Oregon it is so very susceptible that it is regarded commercially as a failure and seldom planted. The same is true of many other varieties.

Spraying to control bacteriosis has met with little success in the past. This may be due in part to the fact that practically all efforts along this line were made during the winter rather than during the growing season when the disease is active. Until comparatively recent years sprays applied at any time of the year might easily have been unsuccessful, especially upon mature trees, which usually attain huge size, because with older types of spray equipment it was virtually impossible to reach all parts of the trees and spray them properly. Within the past decade power-spraying has undergone great changes for the better, but even today to insure thorough coverage it is still necessary to spray very large trees with specially devised long-range guns from a tower erected on top of the spray rig.

In spite of the limitations of the spray machinery of his day, the late Newton B. Pierce, who discovered the cause of the disease and named the organism responsible for it, claimed that applications of bordeaux would reduce infection appreciably. Pierce's reports, written in popular vein and practically devoid of experimental data, were published almost exclusively in several popular magazines which were obtainable only by subscription or purchase. It is not likely that a very large number of walnut growers in California at the time ever saw his articles. In none of his papers does Pierce mention how strong a spray he used, and discrepancies exist in his statements as to just when he applied it. In reading his reports one cannot help feeling that they are fragmentary and merely forerunners of a complete paper or bulletin in which his experimental data would be set down in detail or at least in a more tangible form. Such a bulletin never appeared. Eventually he did publish a technical description of the disease and of the causal organism (42),[4] but in this final report he did not mention spraying at all.

The above criticisms of Pierce's work are not offered with any intention of disparagement whatever. His laboratory studies still remain the basis of all subsequent work by later workers. They are offered merely as a possible explanation of why this phase of his work, which has been verified by the experiments reported in this paper, failed to make a permanent impression on the growers of his day.

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[4] Reference is made in parenthesis to "Bibliography," page 83. Numbers in boldface or heavy type refer to publications particularly pertinent to the subject under discussion. The publications in the bibliography deal primarily with walnut bacteriosis, whereas those cited in footnotes ordinarily do not.

With the walnut industry firmly established in California and grown to its present considerable proportions it seemed logical to attack the problem of control from the standpoint of sprays rather than from that of resistant varieties, to afford, if possible, some relief to the great number of growers whose orchards are severely affected by bacteriosis.

An attempt has been made to have the bibliography given on page 83 as complete as possible up to 1932, when this paper was written. In general unsigned popular articles in magazines or newspapers which have contributed no original research data or observations have been omitted.

HISTORY AND GEOGRAPHIC DISTRIBUTION OF WALNUT BACTERIOSIS

THE POSSIBILITY OF ITS BEING OF FRENCH ORIGIN

The organism which causes walnut bacteriosis is unable to reproduce or even to live for more than a relatively short period in the soil. Similarly it is known to attack only the English walnut and rarely its hybrids. Therefore it seems reasonable to assume that it could not have existed in the absence of walnuts in those localities where it is recognized now, and presumably it was disseminated about the globe on infected stock.

Suspicion often has been pointed at France as the source of the disease, and not without reason, since the walnut industry there is an old one, and many of the plantings made throughout the world during the past fifty or sixty years are easily traceable to nuts and scions imported directly from that country.

In 1907 C. O. Smith (62)[5] observed characteristic lesions on scions imported into California from France. When the scions were grafted on black walnut, typical bacteriosis developed on the new growth close to the old wood. No other trees in the vicinity were diseased at the time, and no new shoots other than those from the French scions ever developed bacteriosis. Also, according to C. O. Smith (51, 53) R. E. Smith saw bacteriosis in walnut orchards in France in 1913.[6]

No French writers have reported walnut bacteriosis in their country, but very recently Wormald and Hamond (107) in England proved con-

[5] Although the bulletin given as citation 62 was written jointly by several authors, credit for the special section on walnut bacteriosis is given to C. O. Smith.

[6] R. E. Smith was thoroughly familiar with walnut bacteriosis at the time he went abroad and is not likely to have been mistaken in its identity. In personal conversation with me he has described the disease which he saw in France and which beyond all reasonable doubt must have been bacteriosis. However, since no cultures were made, the proof of its identity might be challenged on technical grounds. He saw bacteriosis in the vicinity of Grenoble, France, and also near Sorrento, Italy.

clusively that it occurs in France. They conducted successful inoculation experiments with pure cultures of the organism isolated from diseased walnuts growing in the Isère Department, France, and from stem lesions in the same vicinity. Cultural studies showed the organism to be identical with the walnut-blight organism in England and in California.

HISTORY OF THE DISEASE IN CALIFORNIA

About 1890 the disease was first observed in Los Angeles County on trees which had been obtained from a nursery in Orange County. This nursery is known to have imported walnut trees from France a few years earlier. At practically the same time, or very soon thereafter, the disease appeared in Orange County itself (51, 52, 53, 56, **62**). Apparently regarded as a curiosity at first, bacteriosis became so increasingly destructive in southern California and spread so rapidly to other portions of the state that the United States Department of Agriculture detailed Newton B. Pierce[7] to make a study of it. The progress that Pierce made in his work is suggested in the annual report of the Secretary of the United States Department of Agriculture (25) for 1893. By that time the disease was suspected of being of bacterial origin, but inoculation studies to prove the point had not yet been made. In 1896 Pierce wrote a letter describing bacteriosis to the editor of the California Fruit Grower who published it (37). One may gather from the letter that he had isolated the causal organism and with pure cultures had successfully produced hundreds of artificial infections. He also gave the first really accurate description of the disease that had appeared. In subsequent popular magazine articles Pierce reported its latest geographic distribution and very briefly referred to his control experiments (38, 39, 40, 41).

In 1901 he published a technical description of both the causal organism and the disease, referring to the latter as "bacteriosis," as he had done in earlier papers (42).

Around 1900, bacteriosis had become so destructive that the California Walnut Growers Association offered rewards as great as $20,000 for a suitable means of combating it.

In 1905 the California State Legislature appropriated $4,000 to the University of California for the study of walnut bacteriosis, and a laboratory was opened at Whittier, in Los Angeles County,[8] with A. M.

[7] Mr. Pierce's title was Assistant Plant Pathologist, in charge of the Pacific Coast Laboratory of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture at Santa Ana, California. This laboratory is no longer in existence.

[8] This laboratory is no longer in existence.

West in charge, working under the direction of R. E. Smith. Mr. West confirmed Pierce's identification of the cause of the disease but never published his results. The work was then taken over by R. E. Smith, C. O. Smith, and H. J. Ramsey (44, 51, 52, 53, 54, 55, 56, 59, 60, 61, 62, 63, 64, 65), who secured and published much data on walnut blight, as well as walnut culture in general. In this work no specific method of control for bacteriosis was developed.

From 1913 to 1915, W. S. Ballard of the United States Department of Agriculture conducted spraying experiments in the Vrooman orchard at Santa Rosa. The results were never published.

In 1920 Fawcett and Batchelor (23) published results of experiments to control the disease. They found neither a single application of spray very early in the season nor the careful removal of dead wood or infectious material from the trees to be effective.

In 1926 the California Walnut Growers Association, chiefly at the behest of members living in central California, appropriated $2,000 for the further study of the control of bacteriosis, and the writer was placed in charge of the project. The results obtained in the experiments, which were started in the spring of 1927, are given in the present paper.

HISTORY AND GEOGRAPHIC DISTRIBUTION OF THE DISEASE IN OTHER PARTS OF THE UNITED STATES

Oregon was the second state in the Union to report bacteriosis of walnuts when Lewis (31) first described it in 1906. The disease is now recognized in all the walnut-growing districts of that state, and reports of its occurrence and losses occasioned by it have appeared with unusual frequency (1, 2, 7, 8, **9**, 21, 27, 31, **33**, 50, 75, 76, 77, 78, 80, 81, 82, 84, 85, 86, 88, 89, 90, 91, 92, **96, 97, 98**).

Bacteriosis was next reported from Texas by Schattenberg (49) in 1908. Later Waite (68), with Schattenberg's paper in mind,[9] referred very briefly to its occurrence there. The descriptions of the disease given by Schattenberg leave doubt as to its identity.

Bacteriosis was next reported in Louisiana very briefly by Waite (68) in 1914. McMurran (32) also includes Louisiana in his list of states in which the disease occurs.

In 1917, McMurran (32) reported bacteriosis for the first time in Maryland, Pennsylvania, New York, Delaware, Virginia, and the District of Columbia, giving credit for the most part to Waite for diagnos-

[9] According to a personal letter to me.

ing the disease in specimens received in the government laboratories at Washington, D. C., between the years 1910 and 1916.

In 1920, Cook (83) first reported bacteriosis in New Jersey. Two additional reports of its occurrence there have since appeared (17, 85).

Bacteriosis was reported very briefly in 1920 in Alabama (83) and in 1922 in Georgia (85) by the Plant Disease Survey. These are believed to be the only references to the disease in those states.

In 1922, Dana (85) very briefly reported bacteriosis in Washington. Since then it has been reported by the Plant Disease Survey (87, 89, 90, 91).[10]

In 1929, Rosen (78) reported a severe attack of bacteriosis on the leaves of several trees at Fayetteville, Arkansas.

In 1930, the Plant Disease Survey (91) briefly reported bacteriosis in Mississippi.

HISTORY AND GEOGRAPHIC DISTRIBUTION OF THE DISEASE IN FOREIGN COUNTRIES

Reports of bacteriosis in foreign countries are given in the chronological order of their appearance.

New Zealand.—In 1900 Boucher (12) reported and briefly described bacteriosis in New Zealand before it was recognized in any other country or any state in the United States outside of California. It occurs at Auckland (12), the Nelson and Takaka districts, at Christchurch, Banks Peninsula, Timaru, Hawke's Bay, New Plymouth, and Tauranga (28, 29), and at Akaroa (5).

Russia.—An anonymous writer (4) reported bacteriosis in Russia in 1908. The report states that Jaczewski found the disease to be responsible for heavy losses on the Government estate near Sotchi, and Silantiev is said to have reported severe losses in Sotchi itself. Sotchi is near the Black Sea in the vicinity of the Caucasus Mountains. No other report of the disease in Russia has appeared.

Canada.—In 1911, bacteriosis was reported and described in Canada by Güssow (26). It was said to have occasioned severe losses for a number of years in the experimental farms at Agassiz, B. C. The trees originally came from France. No other writer has reported the disease in Canada.

Tasmania.—In 1912, bacteriosis was reported in Tasmania by Rodway (45). Walnut trees in the vicinity of Hobart were said to be severely affected. No other report of the disease on this island has appeared.

[10] Additional reports of the occurrence of bacteriosis over a widespread area in Washington have been received from Dr. F. D. Heald, Chief of the Division of Plant Pathology, Washington Agricultural Experiment Station at Pullman.

Mexico.—In 1912, C. O. Smith (62) reported bacteriosis on walnuts growing along the Pacific Coast of central Mexico. He has made this same report elsewhere (51, 52).

Australia.—In 1914, bacteriosis was reported in Australia by Cole (15) who found it in the state of Victoria, where the trees were said to be severely affected at times. The disease is commonly referred to as "black spot" there and elsewhere on the continent. According to Cole, bacteriosis was seen in Australia as early as 1888 by Mr. Brittlebank, Pathologist of the Victoria Department of Agriculture. This is earlier than the first record of it in California by several years. Cole (16) also has reported bacteriosis in the Ardmona, Bright, and adjacent districts of Victoria.

Bacteriosis was first reported in the State of South Australia in 1922 by Osborn and Samuel (36), who observed that "during the last twenty years [it had] spread to almost all places in the State where walnuts are grown, even to trees 10 or 12 miles apart from any other." Bacteriosis has been reported as occurring specifically in the Mount Lofty Ranges and in the Auburn district by an anonymous writer (6).

Bacteriosis has been recognized in the State of New South Wales since 1903. It causes most damage in the cooler regions, particularly in the Southern Highlands, according to R. J. Noble of the Department of Agriculture of New South Wales.[11]

Chile.—Bacteriosis was reported from Chile in 1917 by Camacho (13). It is commonly known there as the "black plague" (peste negra). In 1926 Capdeville (14) further described the disease and estimated that losses reached as high as 50 per cent at Catemu, Nuñoa, and Maruecos. These are the only reports of bacteriosis from South America.

South Africa.—Doidge (18) reported bacteriosis of walnut in South Africa in 1918. It was said to occur in practically all parts of the country where walnuts are grown and was believed to have been disseminated on nursery stock originally obtained from France. Also it was believed to have been established in South Africa for some few years previous to its identification there.

The disease has been reported specifically from several localities in the Eastern Province, at Eastport, at Clocolan in the Orange Free State, at Potchefstroom in the Transvaal, at Napier in the Bredasdorp District, at Donnybrook in Natal (18, 19, 20) and in the Cango Valley of the Oudtshoorn District (19).

Evans (22) states that bacteriosis was very prevalent in South Africa in 1922.

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[11] Personal letter dated June 10, 1931.

Italy.—Bacteriosis was next reported in Italy in 1923 by Savastano (48). Ferraris (24) also has reported the disease there, giving Savastano's paper as his source of information.

The disease described by Savastano at great length and attributed by him to *Bacterium juglandis* Pierce clearly is not the disease under discussion, and accordingly, has no place in this paper.[12] It is referred to here, and Savastano's paper is included in the bibliography on page 83, because so many authors include Italy in their reports on the geographical distribution of the disease, giving Savastano as reference. Technically no absolute proof of the presence of walnut bacteriosis in Italy exists.[13]

Holland.—Bacteriosis was reported very briefly on walnuts at Zierikzee, Holland, in 1923 by van Poeteren (67). Experimental data and descriptions are lacking. No other report of the disease in Holland has appeared.

Switzerland.—Bacteriosis was reported very briefly in Switzerland in 1924 by Müller-Thurgau and Osterwalder (35). Experimental data and a suitable description are lacking.

England.—Bacteriosis was reported in England in 1927 by Wormald (69), who isolated the causal organism from leaf spots which developed on very young trees the same year that they were received from a nursery in France and planted at the East Malling Research Station. Reports by Wormald and Hamond of subsequent laboratory studies, including suitable descriptions and experimental data, have appeared (70, 71, 72, 73, 74, 94, 107).

Germany.—Whether bacteriosis actually exists in Germany is not clear from the limited information at hand, but Stapp (66) published a description of it in 1928, which was drawn from California publications, and also a technical description of the causal organism based on Pierce's studies. He refers to the disease as *Bakterienbrand der Walnüsse,* but no mention of its occurrence in Germany or elsewhere in Europe is made.

France.—The presence of walnut bacteriosis in France has been recognized definitely since 1931. See page 5.

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[12] The disease described by Savastano and referred to by him as the "dry disease" is characterized by a complete desiccation of the tree, all parts being affected, including roots, trunk, branches, shoots, leaves, and fruit. Affected trees die within a few months to five years after attack. Vague physiological disturbances are noted; excessive production of fruit which fails to ripen, chlorosis, etc. Black spots appear on the leaves and nut husks, the shell and kernel may be destroyed.

Almost the entire article is devoted to a description of the disease in the roots, trunks, and branches. The black spots on the leaves and fruit, which alone seem suggestive of true bacteriosis, are scarcely more than mentioned. Savastano made no cultures, conducted no inoculation experiments.

[13] See footnote number 6, page 5.

DESCRIPTION OF BACTERIOSIS

Walnut bacteriosis is essentially a disease of the leaves, catkins, nuts, and new tender shoots of the English walnut. It never kills a tree, and, under California conditions, it rarely causes any appreciable defoliation even in years favorable to heavy infection. The developing nuts, unfortunately, are very susceptible, which fact alone makes the disease of economic importance. A fine set of nuts at the beginning of the season may be gradually decimated until not a single one remains by harvest time, and yet at close range, the tree itself ordinarily presents no unusual appearance.

In contradistinction to bacteriosis of pears and apples (pear blight, fire blight)[14] caused by *Phytomonas amylovorus* (Burrill) Bergey *et al.*, or bacteriosis of the filbert (filbert blight),[15] caused by *Phytomonas* sp., two diseases which attack all parts of their natural hosts, including fruit, leaves, branches, trunks, etc., walnut bacteriosis never attacks wood that is more than one year old. Similarly it never attacks the roots.

On the Shoots.—Bacteriosis may be expected to occur on the shoots only during that comparatively short period of a few months after their appearance while they are still green, succulent, and tender. As they toughen and become woody in structure their susceptibility diminishes. The degree to which a shoot is susceptible varies throughout its entire length. Thus the older base of a long shoot may have become fairly woody and correspondingly resistant while the growing tip is still succulent and very susceptible to attack if weather conditions are favorable. By the end of the first season, however, all parts of such shoots will have

[14] Recently C. O. Smith successfully inoculated walnut shoots and fruit with the "pear blight" organism. Lesions were produced on both which were indistinguishable from those of true "walnut blight." Natural infection of walnut by the "pear blight organism" is unknown. Smith was unable to infect pear with the "walnut blight" organism. (Smith, C. O., Pathogenicity of *Bacillus amylovorus* on species of *Juglans*. Phytopath. 21(2):219–223. 1 fig. 1931.)

[15] Some writers consider filbert blight and walnut bacteriosis to be identical and group the literature pertaining to these two diseases together in their bibliographies. This seems inadvisable in view of the limited information on the filbert disease which has appeared.

The two diseases apparently present many characteristics in common, but they differ radically in one point; according to descriptions of it, the filbert disease may produce large cankers on the branches and trunks of the trees, whereas walnut bacteriosis cannot attack mature first-year wood, let alone the older branches or the trunk.

H. P. Barss of the Oregon Agricultural Experiment Station has probably done more work with the filbert disease than anyone else. In none of his papers does he make the positive statement that the two diseases are identical or due to the same organism. In a letter received from him while this paper was being written he definitely states that he prefers to reserve final opinion as to the relationship of the two diseases until more experimental data are available.

matured to such an extent that infection can be brought about only with the greatest difficulty, if at all.

Ordinarily infection takes place at or near the extreme tip of the shoot in the tenderest tissue. The entire tip may be killed back for a few inches and in severe cases as much as a foot or even more. But more often the infection is localized and spreads so slowly that the tip of the shoot



Fig. 1.—Bacteriosis of young green shoots of the English walnut. (Natural size.)

grows away from the lesion produced, leaving it farther and farther behind on the shoot. Such lesions may be very small, never attaining a diameter of more than a small fraction of an inch, or they may be several inches long and extend almost completely around the shoot. Occasionally complete girdling takes place, especially when two or more actively spreading lesions coalesce. When girdled the portion of the shoot above the lesion dies as the result of interference with the passage of sap.

The lesions may be so superficial as to involve only the bark, or so deep seated that all tissues are destroyed to the pith. It is in the diseased tissue of such lesions that the organism successfully lives over the winter (Pierce, 37, 39, 40, 41, **42**, 43; C. O. Smith, 54, **62**; and others).

The first visible appearance of the lesion on the shoot is as a minute, translucent or water-soaked dot, usually about the size of an ordinary pinhead or smaller. As the disease continues to spread the inner or older portion of the spot darkens, eventually becoming black. Surrounding

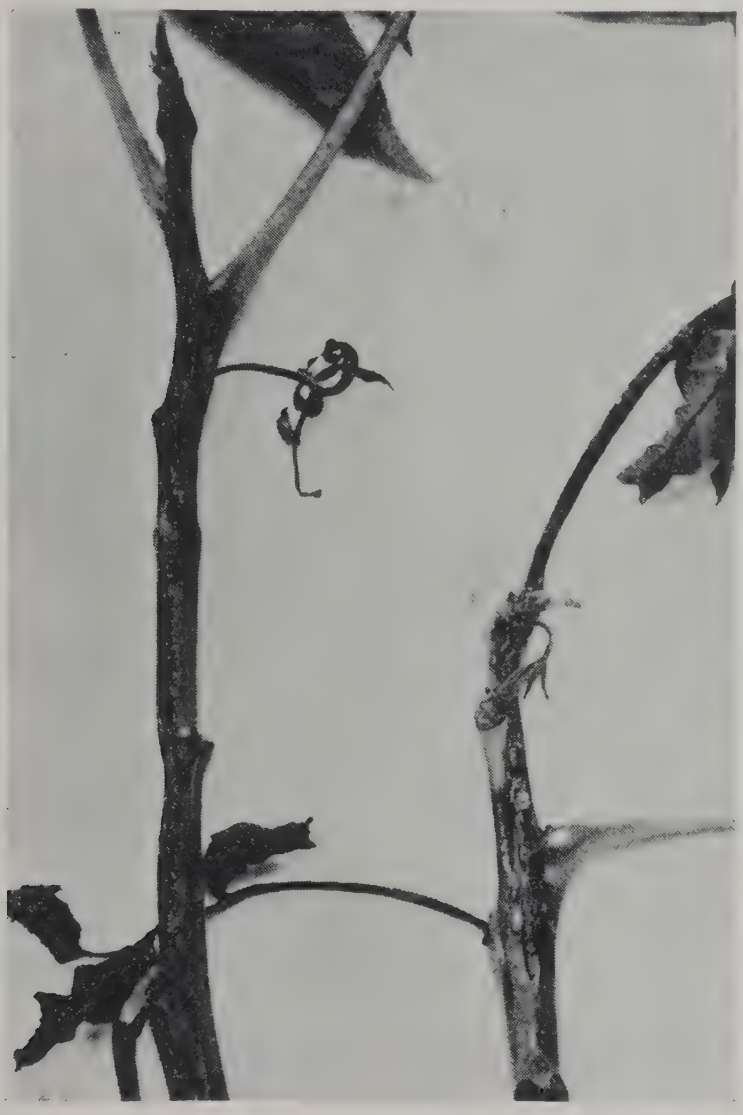


Fig. 2.—Destruction of the terminals of young green walnut shoots by bacteriosis. (Natural size. From Bul. 231.)

the black spot may be seen a narrow band of translucent, water-soaked tissue. The width of this band varies according to the toughness and resistance of the tissue itself, as well as the severity of the attack. When the disease is making little progress the band may be scarcely more than visible to the eye, but in young tender tissue with the disease in an aggressive state it may vary from one to several millimeters in width. When the disease ceases to be active altogether owing to the toughening of the tissue or to other unfavorable conditions, the band disappears entirely,

and the line between the killed, blackened area and the healthy portion is sharply defined. The margins of lesions, whether active or inactive, are generally very irregular (figs. 1 and 2).

As the disease continues to spread in a shoot, the older diseased portions dry out and become somewhat shrunken and depressed. This gives the lesion more of the characteristic appearance of a canker. Generally the epidermis in such dead areas cracks as the tissue dries out.



Fig. 3.—Lesions on English walnut twigs healing over the year following their production by bacteriosis. The organisms which cause the disease live over the winter in the dead and dying tissue of such cankers as these. (Natural size. Photograph by C. O. Smith.)

The dying tissue not infrequently exudes a mixture of decomposed cellular products and bacterial slime, which dries upon the surface as a frosty, whitish, flaky precipitate.

With the disease brought to a halt as a result of the toughening and lignification of the tissue, the process of healing sets in. Evidence of callus formation frequently may be seen around the edges of the cankers late the same season. Figure 3 shows cankers in the process of healing. Healing is completed in the great majority of instances during the growing season of the year following the attack, and the trees apparently are none the worse for their experience.

On the Leaves.—All parts of the leaf may be attacked, including the parenchyma tissue of the leaflets, the midribs, lateral veins, veinlets, rachis, and petiole. After infection, minute water-soaked or translucent



Fig. 4.—Leaves of English walnut affected with bacteriosis. Note that the tissue of the blade, midrib, or petiole may be affected. (Reduced.)

dots appear, which eventually enlarge and darken to a dark brown color as the tissue dies. The margins of such brown spots are a yellowish green in color, lighter than that of the normal healthy tissue adjoining. The individual spots ordinarily never attain a great size and rarely exceed

a few millimeters in diameter. Several smaller spots may coalesce, however, to form a single large one. Typical spots may be circular or irregular in shape.

At times infection may be rather severe at the tender margins of young growing leaflets. In this case a considerable killing of the tissue takes place, which results in malformations and deformities as the healthy tissue grows away from the dead areas (fig. 4).

The killing of a rachis or petiole may lead to the death of the leaflet or leaf, respectively, dependent upon it. Defoliation to any appreciable extent is rare, however.

In California, sunburn and wind damage may manifest themselves as dead irregular brown spots on the leaflets which might be mistaken for bacteriosis. Such spots, however, are confined almost exclusively to the tender, green parenchymatous tissue between the lateral veins of the leaflets, and they rarely lead to distortions or deformities. The lesions developed on leaves of trees poisoned by excessive amounts of alkali or boron in the soil have been confused by some growers with bacteriosis.

On the Nuts.—The nut may be attacked at any time after its first appearance in the spring until it is about ready to drop from the husk in the fall. The period of susceptibility, therefore, is a very long one, which fact constitutes one of the chief obstacles to an easy control of the disease.

Blossom-End Infections.—In its earliest stages of development, namely, before, during, or immediately after pollination has taken place, the nut usually is infected at the blossom-end by way of the stigma.

The blossom of the walnut is inconspicuous, consisting of two small, greenish to reddish, plume-like lobes at the tip of the tiny young nut. These lobes technically make up the stigma, which is the female reproductive process designed to receive the pollen at the time of fertilization (fig. 15, page 64). The surface of the lobes which make up the stigma is very rough and lightly coated with a sticky substance, to insure the retention of any pollen which might fall upon it. This rough, sticky surface probably holds the bacteria equally well also. The tissue of the stigma is exceedingly fragile and tender, and constitutionally adapted to easy attack by the organism. After it has become infected the stigma blackens, the first symptom of disease in it being a tiny black spot at its base or a very thin black streak on its side. From the base of the stigma, the disease penetrates the succulent young nut (fig. 5).

In California the great loss of crop unquestionably is occasioned by the blossom-end infections. The small diseased nuts, $\frac{1}{8}$ to $\frac{1}{2}$ inch in

diameter, are quickly abscissed or shed from the trees, and in years of severe attack the ground may be covered with them.

Although the great bulk of nuts affected at the blossom-end drop from the trees while still very small, an appreciable number do not. In those that remain the disease often seems to be temporarily arrested in its progress; the nuts continue to grow and may even reach maturity. It is not unusual, however, for bacteriosis to become active again in them at



Fig. 5.—Young English walnuts affected with the blossom-end phase of bacteriosis. (Natural size.)

a later date and destroy much husk and shell tissue. Or the disease, arrested to all outward appearances, may work inward through the shell at the blossom-end and destroy the kernel wholly or in part. Nuts containing only the blackened, shriveled remnants of kernels destroyed by bacteriosis are not uncommon at harvest and are generally referred to as "blanks." In the packing house they are referred to as "blows."

Certain strains of the Mayette, generally regarded as one of the most resistant varieties, show a peculiar susceptibility to bacteriosis at the blossom-end. In certain seasons it may be difficult to find nuts that are not affected. The disease makes little progress outside or inside, however, and is confined to a small spot at the base of the stigma. Some nuts are totally destroyed, of course, but at harvest the bulk of the crop is normal in appearance and presents little or no evidence of having been diseased so generally early in its development.

Pollination having taken place, or the period of susceptibility to pollination having passed, the stigma quickly shrivels and disappears. In-

fection at the blossom-end then ceases to take place to any great extent, and lateral or side infections become the rule.

Lateral Infections.—Lateral infections (fig. 6) may take place at any time after the nuts first appear and frequently accompany blossom-end infections, but they predominate later when the period of pollination has passed.

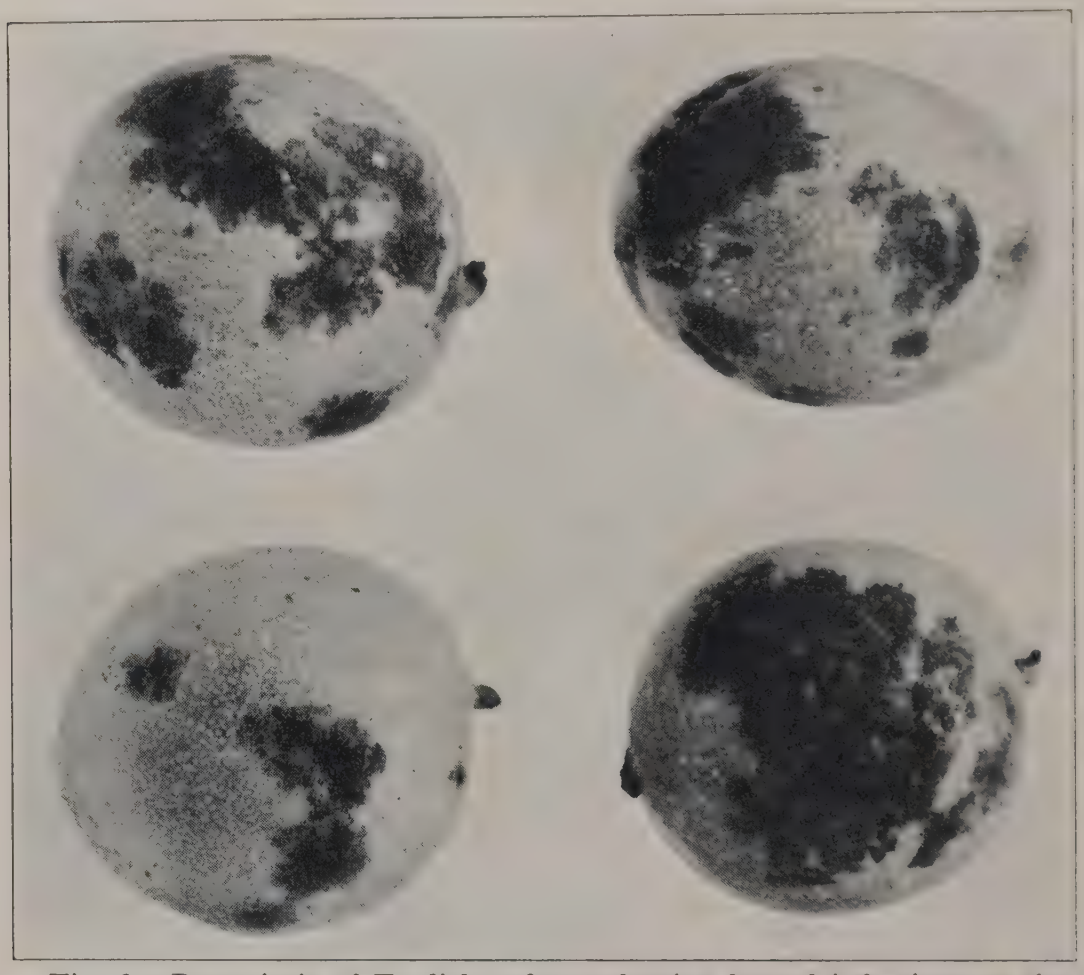


Fig. 6.—Bacteriosis of English walnuts showing lateral infections on the nuts. Note the water-soaked appearance of the tissue at the margins of some of the spots. (Natural size.)

Infections on the sides of the nuts, as on the shoots and leaves, are first visible only as minute, translucent or water-soaked dots. As the disease spreads, the older or central portions of the spots darken and finally become black. A zone or band of translucent or water-soaked tissue, already described on the shoots, and of similarly varying width, persists during the active spread of the disease and makes a border between the healthy and dying parts.

As the lesions enlarge the centers become somewhat shrunken and depressed, and not infrequently the epidermis ruptures (fig. 7).

After protracted wet weather, and particularly immediately after summer irrigation a black slimy sap (fig. 8) frequently bursts through

the epidermis of the lesions. This liquid may be so copious in amount that it collects in great drops and spatters down onto healthy leaves and nuts below. The liquid is swarming with the bacteria that cause the disease and frequently serves as a medium to introduce the organism to

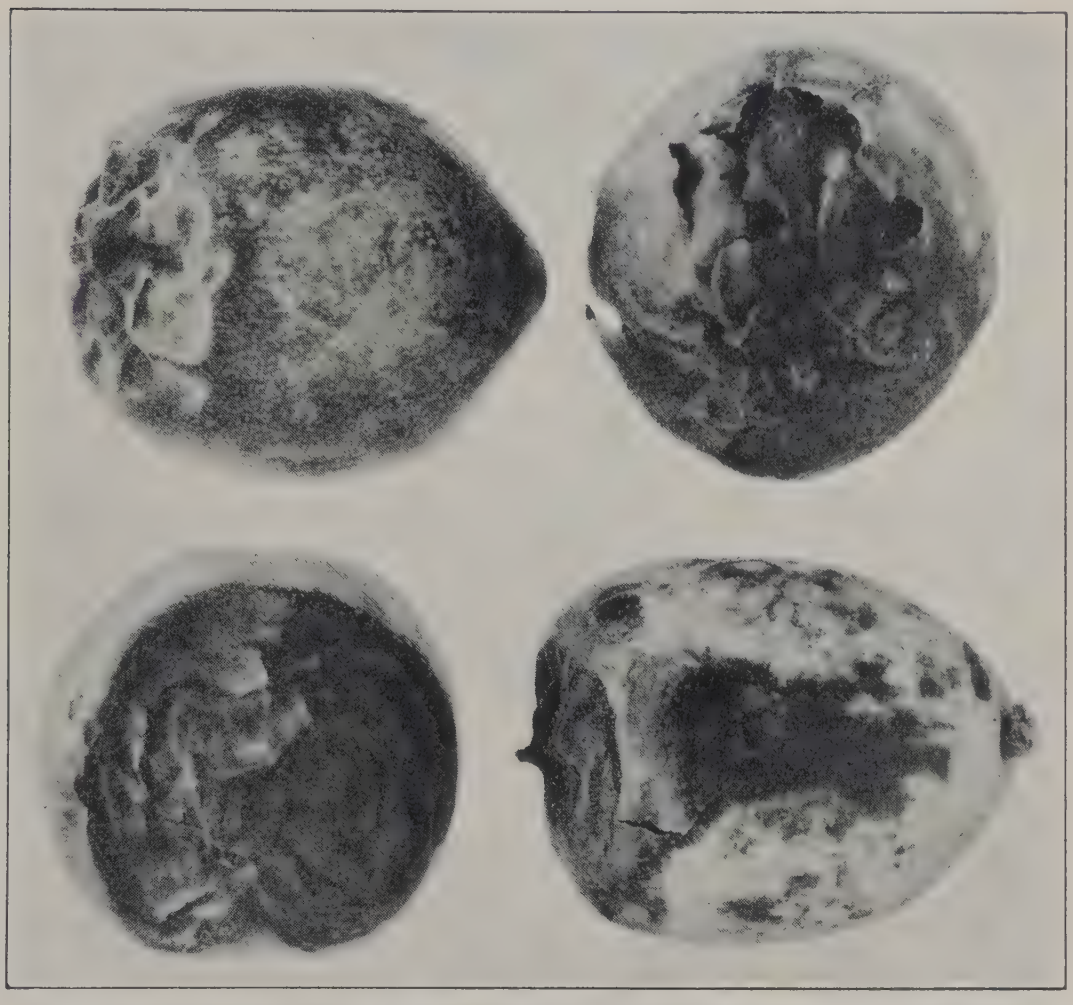


Fig. 7.—Advanced stage of bacteriosis of English walnuts. (Natural size.)

healthy nuts. Ants, flies, and many other insects are attracted to the juice, and it may be that they too further disseminate the bacteria on their mouth parts and feet. See "Insects as Carriers of the Organism," page 30.

The depth of the lesions and the extent to which nuts may be injured by them depends on their age at the time of attack. Nuts attacked at any time before, during, or immediately after the pollination period, almost invariably are completely destroyed or shed from the tree. As the nuts grow larger and shell tissue begins to develop, the disease does not progress as rapidly nor do the nuts fall so readily from the tree.

In its earliest developmental stages, the newly formed shell tissue is easily attacked and destroyed, and the developing kernel within, still in the "milk" or "jelly" stage, is likewise quickly rotted to a black, slimy

mass. A little later, when the shell is harder, it may be perforated and the kernel may be destroyed or at least blackened and shriveled to worthlessness (fig. 9). Finally the shell attains a toughness which makes it impenetrable to the bacteria, but some substance, possibly by-products of



Fig. 8.—Bacteriosis of English walnuts showing drops of the black, slimy sap that oozes from the lesions immediately after irrigation or heavy rain storms. (Natural size.)

the bacteria or even decomposition products from the decayed husk tissue itself, may filter through the shell and produce discoloration or even partial shriveling of that portion of the kernel immediately under the diseased area on the husk. During the last stage of its maturity neither the bacteria nor their by-products can penetrate the shell. At this stage the kernel is not apt to show shriveling or discoloration, but the outside of the shell may be badly stained and the nut rendered a cull because of

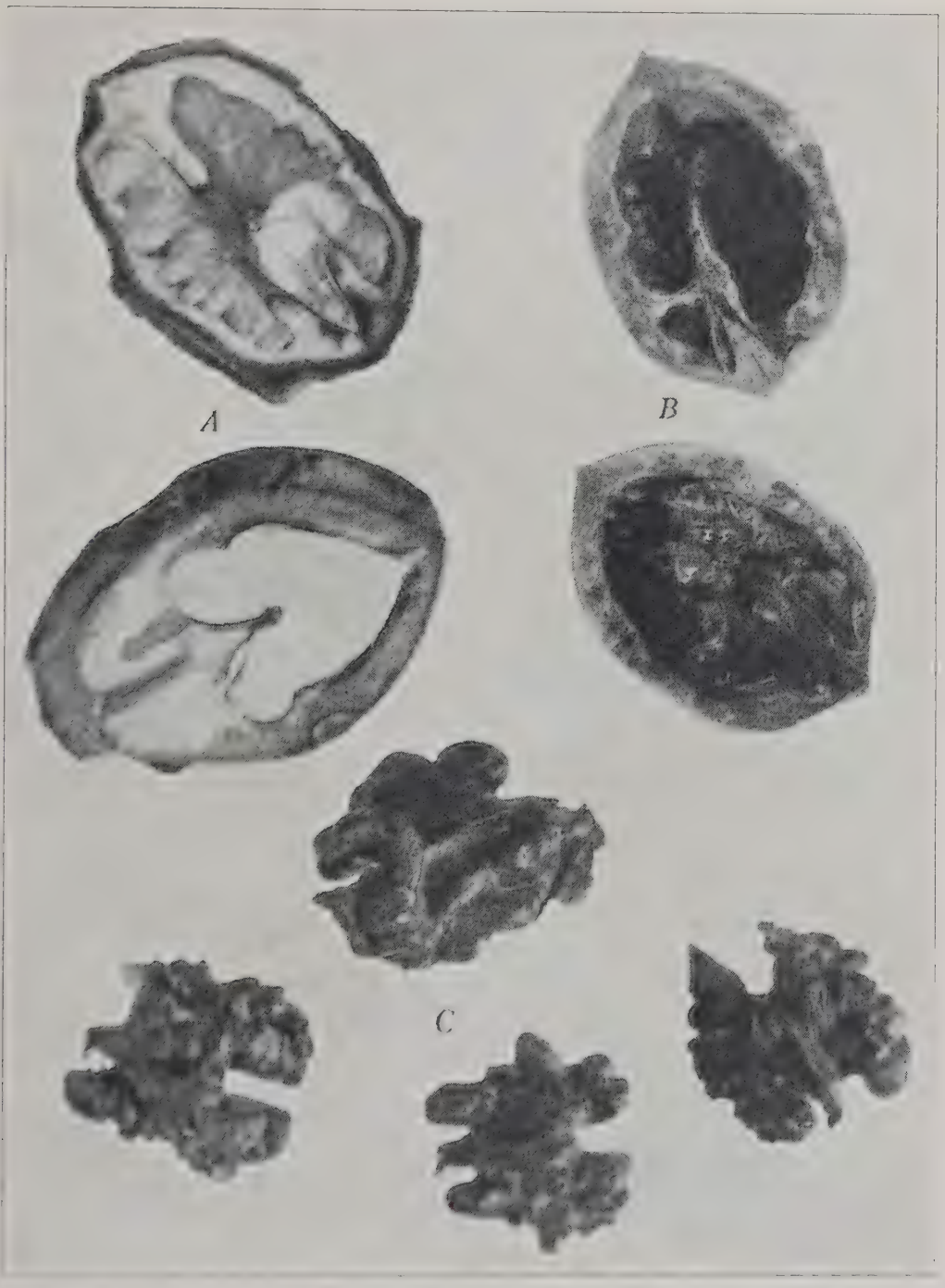


Fig. 9.—Bacteriosis of English walnuts: *A*, two views of healthy walnut meats in cross section; *B*, total destruction of the kernel within the shell by the disease; *C*, kernels attacked later than in *B*. They are shriveled, black, and unfit for food. (Natural size.)

it. No bleach is sufficiently powerful to remove the stain from the shell without injuring the quality of the kernel. Not infrequently much of the rotten husk tissue clings tenaciously to the shell and makes the nut even more unsightly (fig. 10).

The above description is concerned only with the disease in its nat

ural or uninterrupted progress in infected nuts. There are times, however, when the disease is arrested, and the nut survives the attack. This rarely takes place when the nut is very small, but frequently may be observed when it is more mature. In such cases the nut may continue its development but at harvest time show perforations of the shell, deformity, and other imperfections proportional to the damage done at the time the disease was arrested.

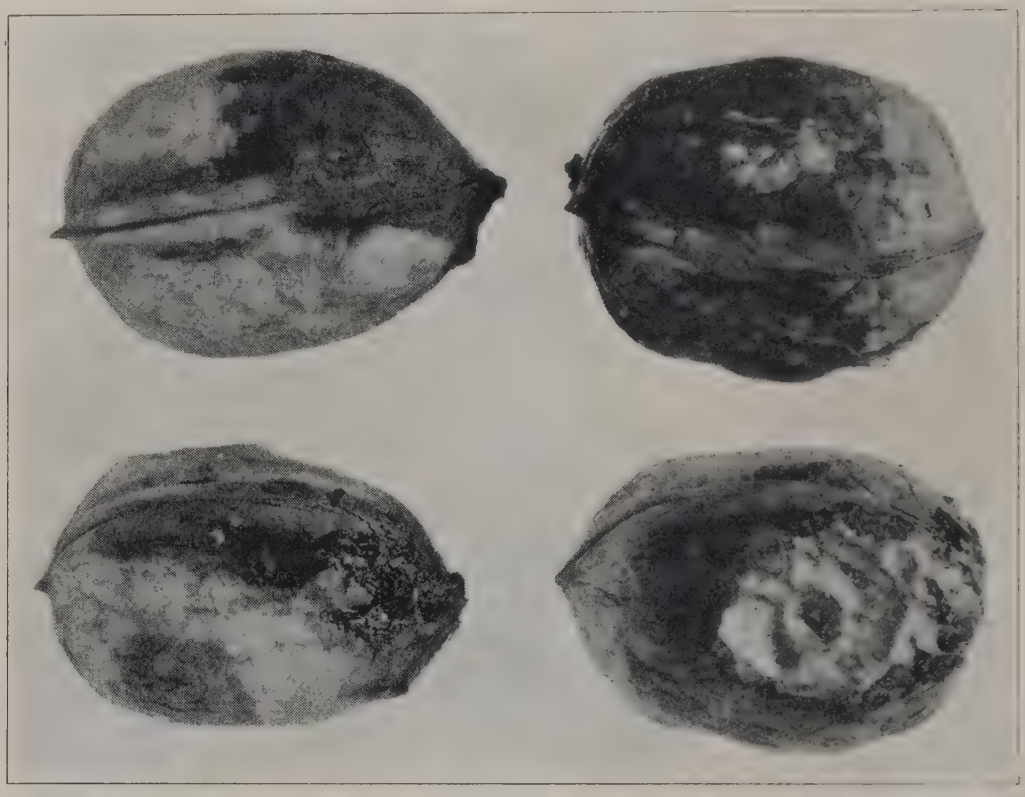


Fig. 10.—Stain produced on the shells of English walnuts by bacteriosis which causes the nuts to be graded as culls regardless of the quality of the kernels. Note the decayed husk tissue adhering to the shell of several of the specimens. (Natural size.)

Infections taking place very late in the season make slow progress as a rule. Spots of varying size are developed on the husk as usual, but generally they tend to be small. These lesions are more or less confined to the outer tissues of the husk and may not even reach the shell. No damage to the nut results from such attacks.

Mere blackening or shriveling of a kernel is not always attributable to the effects of bacteriosis. Many other factors, largely physiological, frequently bring either about. Drought may cause shriveling, and sunburn may cause both darkening and shriveling of the kernels (fig. 11). Sunburn is often mistaken for bacteriosis by growers who have not studied the disease closely. They are easily distinguishable, however. Husk tissue that is severely sunburned is dry and leathery in contradistinction to blighted tissue, which is soft and water-soaked. Also sunburned

husk tissue does not cling to the shell as does tissue affected with blight. There are other dissimilarities but they need not be mentioned here.

Improper harvesting and processing methods can utterly ruin the color of both shell and kernel; to delay husking nuts that have been har-



Fig. 11.—Severe sunburn of English walnuts showing the damage done to the husks, shells, and kernels. The circular stripe on the husks and shells is characteristic only of severe burns. (Natural size.)

vested may cause the shells to be stained and the skins of otherwise perfect kernels to turn almost black.

Diseased nuts usually fall of their own accord from the tree. Ordinarily the slightest jar will dislodge them. Occasionally, however, the organism works its way rapidly through the tissue into the stem and kills it before the nut can be shed. In such cases the nut remains hanging

to the branches as a "stick-tight"[16] indefinitely or, at least, until shaken off by wind storms. Infections at the base of the nut near the stem or on the stem itself easily may lead to the production of stick-tights.

Occasionally the disease may pass through the stem of the nut into the base of the twig to which it is attached and cause the development of a small canker there.

On the Catkins.—Apparently the catkins are not as susceptible to the disease as the nuts, but under suitable conditions they too may be attacked. The disease never develops until after the catkins have broken dormancy and are considerably elongated in the spring.

When affected with bacteriosis the individual florets which bear the pollen turn black (fig. 12) and present a somewhat water-soaked and wilted appearance, which contrasts sharply with the green, turgid appearance of healthy florets of the same catkin. A single floret may be affected, or all the florets on one side or at the top or at the bottom of the catkin may show the disease. Similarly the rachis may be attacked at any point along its length. Distortions and deformities in catkins often result from the killing of local areas only (fig. 12).

C. O. Smith (54, 55, 56) has shown that pollen may become infected. It may be that bacteria-laden pollen falling upon the flower parts of the young nuts is responsible for much of the blossom-end infection, but this point has not been proved.

SPECIES OF JUGLANS AFFECTED BY THE DISEASE

Bacteriosis affects the English (Persian) walnut (*Juglans regia* L.) almost exclusively, as far as known. According to C. O. Smith (51, 53, 62), under suitable conditions, the disease may be induced artificially in eastern or American black walnut (*Juglans nigra* L.), the southern California black (*J. californica* Wat.), and the northern California black (*J. californica* Wat. var. *hindsii* Jepson) by inoculating the tender shoots and leaves with the bacteria by the needle-puncture method. In one instance C. O. Smith (62) noted that bacteriosis had spread naturally from artificially infected leaves of northern California black walnut to nearby leaves on the tree. The writer occasionally has seen natural infections on the leaves of suckers on California blacks topworked to English varieties which were seriously diseased at the time. Ordinarily, even in nurseries where the disease is apt to affect English walnut seedlings severely, it is never seen on black stock of any kind.

The butternut (*Juglans cinerea* L.) and the Japanese walnuts (*J.*

[16] The term "stick-tight" is used also to designate a nut which cannot be separated easily from the husk.

sieboldiana Maxim and *J. sieboldiana* var. *cordiformis* Makino) may also be infected by the needle-puncture method, according to C. O. Smith (62).



Fig. 12.—Bacteriosis of the catkins of the English walnut. Note the blackening of a local area on the rachis or stem of the catkin on the right. Also note that the healthy florets on the catkins are light in color, the diseased ones are black. (Natural size. Photographed by J. T. Barrett.)

C. O. Smith (41, 53, **62**) has found bacteriosis occurring naturally on leaves of Paradox seedlings (a hybrid of the California black walnut and the English walnut) in the nursery, but never on Royal hybrids (a cross between eastern and California black walnuts). But, as indicated above, they may be infected artificially under suitable conditions.

Commercial Varieties Affected by Bacteriosis.—There is absolutely

no known variety of the English walnut which is immune to bacteriosis and not many which even show any great resistance. A few varieties do show what appears to be a definite resistance to the disease, but the characteristic is traceable to their peculiar habit of foliating late in the spring rather than to any inherent, physiological properties. Thus, the Franquette, a very late variety, frequently escapes the disease in central California, where the annual rains are practically over at the time this variety breaks the bud. Farther north, however, in Oregon, where the climate is much damper, the Franquette crop may be wiped out.

While all commercial varieties and seedling trees may be regarded as subject to attacks of varying severity according to the climatic conditions under which they are grown, the following have been specifically reported as susceptible and discussed in the literature: Bishop (62); Chaberte (73); Chase (62, 89); Concord (54, 62, 89); Ehrhardt (10, 54, 55, 56, 85); El Monte (33, 62, 98); Eureka (1, 10, 23, 54, 55, 56, 89); Franquette (1, 8, 9, 34, 44, 50, 54, 56, 62, 73, 80, 89, 96, 98); Gladys (73); Grove (10); Mayette (34, 44, 50, 56, 73, 89, 96, 98); Meylan (34, 50); Meylannaise (73); Parisienne (73); Payne (10, 64, 65, 89); Placentia (10, 23, 54, 55, 56, 62, 64, 65, 85, 89); Pride of Ventura (62); Prolific (62); Santa Barbara Soft Shell (62); Santa Rosa (62); seedlings (9, 10, 23, 32, 54, 55, 62, 85, 96, 98); Treyve (73); Vourey (73).

While true physiological resistance in any variety is difficult to recognize, it is a very easy matter to see that some individual trees are more susceptible to the disease than others. This applies especially to seedling trees. The degree to which each is affected by bacteriosis varies greatly, but in practically all seedling orchards there is a tree or two so susceptible to attack that it is outstanding. Owners not infrequently put identification marks on such trees and on request can readily point them out.

It is impossible to recommend any one variety as suitable for general planting everywhere. The grower should select the variety best adapted to his locality, taking into account not only its commercial possibilities there but also its probable degree of resistance to bacteriosis under the climatic conditions which prevail in the vicinity. In a broad way, however, he can be guided in making his choice by the time a variety starts growth in the spring. It would be foolish, for instance, to plant such early varieties as the Santa Barbara Soft Shell, Ware's Prolific, Placentia, or Payne in the coastal counties of Oregon where the rainy season persists for months after growth has started in these varieties. From the standpoint of bacteriosis alone these varieties are much more suited to regions farther south, in central or southern California. Many other factors, of course, must be considered in selecting a variety, but a discussion of them is beyond the scope of this bulletin.

THE ORGANISM RESPONSIBLE FOR BACTERIOSIS

Pierce's Description of the Organism.—In his only technical description of the organism which causes walnut bacteriosis, Pierce (42) named it *Pseudomonas juglandis.* In 1905, E. F. Smith (57) changed the name to *Bacterium juglandis* (Pierce) E. F. S., and in 1930, a committee of the Society of American Bacteriologists[17] reclassified it according to a newer and more modern system calling it specifically *Phytomonas juglandis* (Pierce) Bergey *et al* (11).

The following is a verbatim copy of Pierce's original description of the organism and its culture characteristics:

Pseudomonas juglandis, n. sp.—A short, rod-shaped microorganism with rounded ends, actively motile, bearing a single long polar usually wavy flagellum. Length of organism, taken from colony in acid gelatin, set directly from walnut, and stained with gentian violet, 1–2 μ, according to whether the germ has just divided or has elongated but not yet divided. Just before separation a pair of germs will usually average about 2 μ in length. Average breadth of organism about 0.5 μ. Occurs singly or in pairs, and sometimes in shorter or longer chains. Produces a bright chrome-yellow growth on potato and many other media. When growing normally on potato the starch is so acted upon by a diastatic ferment produced by the organism, that it is altered throughout a wide band beyond the margin of the culture of organisms. This band of converted starch may extend 0.5–1 cm or more beyond the margin of the growth of germs, appears white to the eye, fails to show normal starch reaction to iodine, yields marked grape sugar reactions, has an exceedingly sharp and well defined limiting outline, often passing so sharply through a cell as to include only the starch grains on one side of the cell. This broad and distinct ferment band distinguishes this organism at once from *Pseudomonas stewarti* and *P. hyacinthi,* as well as from the more nearly related *P. campestris,* which occasionally forms a weak but much narrower band, and from all other uniflagellate organisms studied. Organism prefers neutral or acid reaction of culture medium, a moderate degree of alkalinity inhibiting growth; it liquefies neutral and acid gelatin. Produces no gas in fermentation tubes of sugar solutions; growth confined to neck and bulb of tube, hence aerobic, no growth under mica plate. Colonies in malic acid potato gelatin and agar circular; at first clear but soon decidedly yellow, margin sharp. This organism is distinguished from *P. campestris,* the most nearly related species of the genus, aside from the characters already assigned, in producing an abundant and bright yellow pigment on the surface of extracts of the leaves of the following plants, while *P. campestris* produces little or no pigment upon such extracts: walnut *(Juglans regia),* magnolia *(Magnolia macrophylla),* fig *(Ficus carica),* castor bean *(Ricinus communis),* loquat *(Eriobotrya japonica).*

Since his paper appeared, several workers in this country and abroad have repeated Pierce's laboratory studies and have verified his findings

[17] For a discussion of this newer genus, see: Burkholder, W. H. The genus *Phytomonas.* Phytopath. 20(1):1–23. 1930.

in the main. Doidge (18), C. O. Smith (62), and Wormald (73) have reported additional laboratory studies of the organism. Bergey (11), Elliott (21), and Stapp (66) have given descriptions of the organism and its culture characteristics, largely based upon the work of Pierce and others.

The Effect of Desiccation and Sunlight on the Organism.—C. O. Smith (62) has shown that the organism can withstand desiccation for as long as seventy-three days when kept in the dark but dies after four days' desiccation in the light.

Just how much direct sunlight the organism can stand has not been reported, but it probably will not stand desiccation and direct sunlight in combination for more than an hour, if that long.

Longevity of the Organism in the Soil.—No one has reported isolating the organism from the soil itself. Repeated attempts by the writer over a period of years to isolate the bacteria from the soil under badly diseased trees have failed. Even moist soil rich in the humus of decayed walnut husks found around packing houses failed to yield the organism. Cultures were made from surface soil and from that taken at different levels to a depth of 18 inches.

C. O. Smith (54) found that the organism does not survive long when inoculated in either sterilized or unsterilized soil. Cultures made at short intervals indicated a rapid disappearance of the bacteria starting within 24 hours after the time of inoculation. In sterilized soil the organism lived the longest and could be recovered as long as eighteen days after inoculation, but in unsterilized soil, kept at 20° C, it disappeared in from six to nine days.

Source of the Organism.—Pierce states in most of his papers that the bacteria live over the winter in the dead tissue of the affected shoots and in the old rotten nuts and leaves on the ground. A number of workers have verified his findings on rotten nuts and diseased twigs but not on the leaves. The work of C. O. Smith in this connection is particularly pertinent to California conditions. Smith (53, 54, **62**) isolated the organism from diseased epidermis, wood, and pith of shoots and from rotten nuts hanging in the trees at approximately monthly intervals between the fall and the following spring when the new growth and young nuts had appeared, thus proving such material capable of harboring the organism over the winter.

It is the general opinion of investigators—and there seems to be no reason for doubting it—that the living organisms are washed out of the old lesions on the twigs and decayed nuts by the winter and spring rains and spattered onto the susceptible growing shoots, leaves, and nuts.

More recently Miller (98) has isolated the organism from dead buds. C. O. Smith (53, **54**, 55) isolated the organism from the surfaces of healthy leaf and catkin buds in the early spring before growth had started. It is his belief that the organism is commonly disseminated on the healthy buds of scions. He was able to induce little or no infection by inoculating dormant buds even by severe or extreme methods. Leaf buds inoculated when dormant produced healthy foliage in the spring, and catkin buds produced healthy catkins. But inoculations made after the buds had started to grow were increasingly successful according to the stage of development the new growth had reached at the time the inoculations were made. The deduction to be drawn from this is that the buds or the new growth from them must reach a certain maturity or stage of development before infection can take place.

The Relation of Atmospheric Moisture to Infection.—Probably no outside factor plays so great a role as atmospheric moisture in bringing about infection. That the disease is worse in wet years is universally recognized. Nothing is so conducive to infection as a heavy, protracted rainstorm. But even other forms of precipitation on the susceptible parts such as moisture from fogs, dew, etc., are frequently sufficient to bring about an attack.

In California the greatest loss occurs during the wet months of early spring when the nuts are still small. As the long dry season approaches and the rainfall becomes more scanty, infection decreases. After May it may even be negligible. On the other hand, damp summer fogs and mists frequently prevail along the coast and at times penetrate to the interior valleys where walnuts are grown. In their wake late or secondary infections may follow.

Probable Method of Infection.—The epidermis of the susceptible parts is possessed of a multitude of breathing pores called stomata, which are capable of being opened or closed by the plant according to its physiological requirements. In dry weather, particularly when water is scarce, the breathing pores are apt to be closed, or nearly so, to prevent an excessive loss of moisture. In wet weather, and especially after irrigations, the breathing pores are apt to be wide open to facilitate the passage of excess sap out of the plant tissues. While no one has reported actually seeing the walnut-blight organism enter a breathing pore it is generally accepted that they do. Considering the fact that the organisms are motile and able to swim relatively long distances in water it does not seem unreasonable to suppose that many of them find their way through the open pores. Wounds and abrasions also offer a means of easy entrance to the inner tissue. Once within, an ample food supply permits of the multiplication and destructive activities of the parasite.

That the organism can attack the susceptible parts readily through the medium of water is evidenced by the ease with which infections can be induced artificially with it. Bacteria from a pure culture (or the juice expressed from the rotten nuts) when added to water and atomized onto healthy nuts will attack them. Diseased spots may become visible as soon as two or three weeks after atomizing and steadily increase in number until there are hundreds of them on individual nuts at the end of a month. (C. O. Smith, 56, 62, and author's observations.) C. O. Smith (62) also found that infection was slight when the fruit was atomized in warm sunny weather. This bears out the field observations of many, that infection does not take place so readily during brief, light showers or foggy spells when the water is quickly evaporated from the surface of susceptible parts.

Mechanical Injuries.—The simplest, quickest, and surest way to produce bacteriosis experimentally is to dip a needle in a culture of the organism and prick the epidermis of any susceptible part such as the leaves, young shoots, catkins, or nuts with it. The bacteria introduced into the wound quickly multiply, and in about nine days or longer, according to external conditions, the characteristic rot appears. It stands to reason that any mechanical injury to the susceptible parts such as an abrasion, limb puncture, scratch, etc., may give rise to the disease if by any chance the organism should be introduced into the wound. Many infections clearly take place in this way.

Insects as Carriers of the Organism.—C. O. Smith (62) proved experimentally that insects may carry the germs on their feet and mouth parts, particularly when they have walked through or fed upon the bacterial exudate which so frequently oozes from the decayed spots. (See fig. 8, p. 20.) To what extent they spread the disease by tracking the organism over healthy susceptible tissue is not known, but it is conceivable that some infection follows the spread of the organism in this way, especially in wet weather. Organisms tracked onto dry, uninjured epidermis exposed to direct sunlight, probably not only are unable to make an attack but are likely to be killed by the disinfectant action of the sun.

The walnut aphid (*Chromaphis juglandicola* Kalt.) has been suspected of disseminating the blight bacteria. The insect confines its attacks, however, almost entirely to the leaves, which ordinarily are little affected by the disease. It does not seem probable, therefore, that aphids are responsible for the spread of bacteriosis in the nuts to any great extent.

In 1927 an experiment was undertaken to determine whether the disease could be reduced in amount by controlling the walnut aphids. A block of sixteen trees in the Anderson-Barngrover Ranch Company's

orchard at Linden was sprayed for the first time just as the new growth and catkins were beginning to appear, and then at frequent intervals, never exceeding one month, throughout the balance of the season with an insecticide of the following formula:

Black Leaf 40 (40 per cent nicotine sulfate)	2 pounds
Caustic soda	1 pound
Water	200 gallons

Additional applications of 2 per cent nicotine dust were given when the balance of the orchard was dusted for aphid control. The control of aphids was excellent in the experimental plot, poor in the trees outside of it. But the crop on the sprayed trees was severely attacked by bacteriosis regardless of the control of the aphids, and to the eye presented no less disease than that on unsprayed trees. The experiment described is admittedly limited, but the results would seem to indicate that the control of aphids at least does not necessarily effect an appreciable control of the disease.

Insects which bite or bore into the young shoots or nuts may enable the disease to get a foothold. Not infrequently bacteriosis starts at holes in the nuts made by the husk maggot and the larvae of the codling moth, two serious pests of the walnut in certain parts of California.

LOSSES DUE TO BACTERIOSIS IN CALIFORNIA

It is impossible to give the loss occasioned the state of California by bacteriosis in exact figures. All authorities are agreed, however, that the loss of crop due to it far exceeds that of all other walnut diseases put together. Growers' estimates of losses are apt to be too low rather than too high, because usually they are made late in the season when the diseased nuts hanging in the trees or lying on the ground are clearly evident to the eye. The greatest loss of crop, however, ordinarily occurs very early in the season when the nuts are still very small. Such affected nuts fall, quickly disappear from sight, and the quantity of them is generally underestimated as a consequence.

Only very general estimates and fragmentary observations of seasonal losses in the more important walnut districts of California are available. Often these are contradictory. Twenty years ago C. O. Smith (62) pointed out that although the walnut acreage at that time in southern California had multiplied many times during the previous decade, the total walnut crop of the state had not increased during the same period. He attributed this largely to the ever increasing destructivity and spread of bacteriosis. The disease is no less serious today than it was

then, consequently the loss to the state since it was first introduced must have run well into the millions of dollars.

C. O. Smith (62) estimated the average loss occasioned by bacteriosis during the ten years previous to the time he wrote at 50 per cent.

He points out that in individual years the crop may be so badly attacked that not a single healthy nut remains at harvest. The writer frequently has made similar observations. Such losses must be regarded as 100 per cent. On the other hand bacteriosis may be present in some orchards year after year to no greater extent than necessary to give the crop a desirable thinning. But many orchards likewise are visited year after year by the disease in a distinctly more severe form. One grower in Santa Clara County whose orchard is well known for its fine trees of mature age told the writer that he never yet had learned their full bearing capacity because of the consistent annual losses occasioned by bacteriosis ever since they had come into bearing. This situation probably prevails in many other orchards.

Growers in the counties bordering on San Francisco Bay as well as in the interior in San Joaquin County readily agree that in years favorable to bacteriosis their losses vary from 50 to 80 per cent. In all of these localities the loss may be as little as 10 per cent when climatic conditions are unfavorable to the disease.

In Santa Barbara County many orchards have been observed in which the loss could be estimated conservatively at 75 per cent. Mr. Hooper, formerly Walnut Extension Specialist of the University, believes the average loss in this same region over a period of years to be about 25 per cent.

Numerous orchards have been visited in Los Angeles County in which the loss could be estimated conservatively at 50 per cent. Observers in Orange, Los Angeles, and other southern counties, are not inclined to regard the average annual loss as high as C. O. Smith did in these same localities twenty years ago. This is not at all improbable, considering the drought that has prevailed for a decade in the state and in southern California in particular.

The losses that have been described thus far may be called direct losses. They are concerned merely with the extent to which bacteriosis may destroy the crop in the trees. Indirect losses, less obvious, may be traced to bacteriosis also. Probably no factor has contributed more than bacteriosis to making necessary the complicated routine of the modern walnut packing-house. To separate the good nuts from the diseased (blanks or blows), specially designed vacuum machines must be employed. Also, otherwise good nuts rendered culls because of blight stain

on the shells must be sorted out by hand. To accomplish this the crop must be passed along moving belts in front of workers who examine each nut and remove the blemished ones by hand. The cost of machinery and labor annually employed throughout California in the production of a standard merchantable pack of walnuts free from bacteriosis or its effects is very great. Similarly the cost of converting the blight culls into useful by-products is no small item.

CONTROL EXPERIMENTS

METHODS OF CONDUCTING THE EXPERIMENTS

The Plan of the Experiments.—Because no previous experiments reported in the literature included the application of sprays during the active growing season of the walnut, it was considered advisable to try to effect a control of the disease with spring and summer sprays. Also, since the literature had consistently reported nothing but failure with dormant or winter sprays it was decided to exclude them from the experiments, for the time-being at least. Lastly, because the period of susceptibility of the walnut is an exceedingly long one, lasting from the time the nut first appears in the spring until it is ripe and ready to drop from the husk in autumn, it seemed improbable that any spray schedule could succeed that did not include the use of several applications of any given material to the same trees, since no one application of spray or its effects lasts indefinitely.

To test out the above ideas a system of moving plots was devised to permit the application of any spray solution to a constant unit of trees in single or multiple applications and in gradually increasing or decreasing numbers over any given period of time with a minimum of labor and trouble. Figure 13 shows a diagram of a moving plot.

According to the plan, 40 trees were sprayed with a given spray solution at definite intervals, but with each additional application of spray the entire plot was moved forward so as to include 10 new unsprayed trees at the front while 10 previously sprayed trees were dropped from the rear. Thus as a result of overlapping, a series of definite, smaller blocks of 10 trees were created which were sprayed one, two, three, and four times each; also blocks of 10 trees, each of which received all sprays but the first, all but the second, and none but the fourth giving a total of 7 blocks of 10 trees each, or a total of 70 trees to each moving plot treated with any one spray material.

Check plots of unsprayed trees, never less than 10 in number, invariably were left at the front and rear end of any moving plot for the

sake of comparison. Also, any one entire moving plot sprayed with a given solution always was separated from another sprayed with a different one by at least one row of trees to avoid the possible influence of wind-blown spray from one plot on the other. Usually as many as three rows separated the moving plots and in some instances many more, and these unsprayed trees also served as checks.

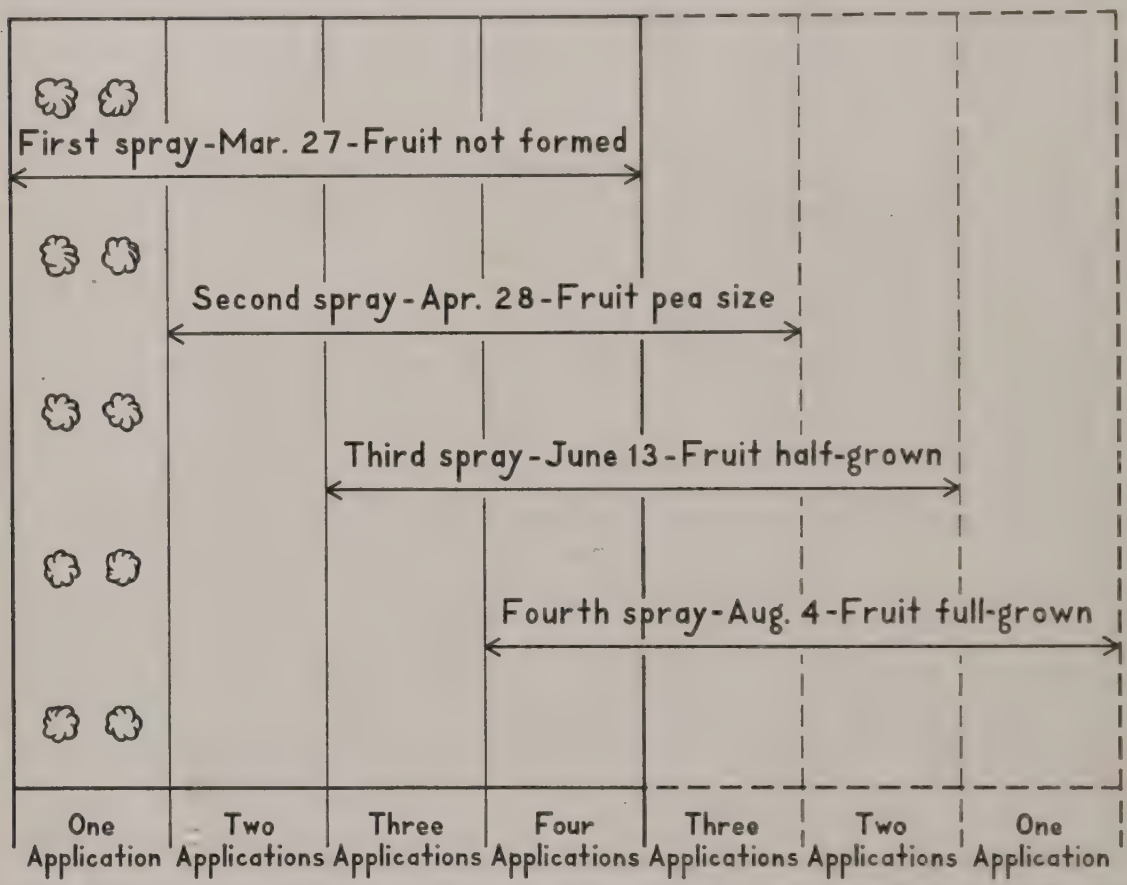


Fig. 13.—Diagram of a typical moving spray plot. This type of spray plot possesses many advantages in spraying walnut trees experimentally for the control of bacteriosis.

Figure 13 shows the spray schedule followed the first year. The first application of spray was made when the buds were bursting and the first new growth had appeared but before any appreciable number of young nuts were exposed. The second application was made when the young nuts had reached the size of peas, the third when the nuts were half-grown, and the fourth when full-grown. In subsequent years various modifications in this schedule were made until a satisfactory one was found. See "How to Spray to Control Bacteriosis," p. 61, for the spray schedule now recommended to growers.

Where the Experiments Were Conducted.—The spraying experiments were conducted at widely separated points in California on both seedling and budded varieties. Most of the work on budded varieties was done in San Joaquin County near Linden, whereas the work on seed-

lings was done largely in southern California in numerous orchards scattered through Santa Barbara, Los Angeles, and Orange counties. Cooperative work with H. P. Barss, Oregon State College, who sought assistance in combating the disease in Oregon, was undertaken the third year of the experiments and certain interesting data were received from him.

How the Sprays Were Applied.—The sprayings were made with a modern spray rig of 400-gallon capacity. The rig was equipped with 12-inch iron tires shrunk to the wheels, a feature which made it possible to negotiate soft wet ground in the spring with a full load of spray. An extension tower from the top of which very tall trees could be sprayed effectively was also provided.

A constant pressure of 500 pounds was maintained for each application made except on small trees, when the pressure was reduced to meet the circumstances. For trees of moderate size, ordinary spray guns were used, but for large trees, shade-tree guns and the Spencer walnut-tree gun were frequently employed. No. 8 and No. 9 tips were used in the Spencer guns, but smaller ones (Nos. 6 and 7) may be obtained for work on smaller trees.

Spray Materials Used.—Since practically all of the various materials and combinations of materials used in the experiments proved utterly valueless in the control of bacteriosis and often harmful to the trees as well, a detailed discussion of them would be of little value at this point. See the "List of Materials Tried with Doubtful, Limited, or Unfavorable Results," p. 77. Those materials which gave any appreciable benefits are discussed under the section entitled "Results Obtained Experimentally with Sprays," p. 36.

Spray Terminology.—The following terms have been used to designate the time when the sprays were applied or the size of the nuts when they were sprayed. A "pre-bloom spray" is one applied when the buds are bursting and some of the new growth has developed but when few or none of the nuts have appeared. This stage of development in the trees is referred to as the "pre-bloom stage." A "post-bloom spray" is one applied when the flowers at the ends of the young nuts have faded and turned brown. This stage of development is referred to as the "post-bloom stage." The terms "pea stage" and "olive stage" indicate rather loosely that the young nuts have reached the size of ordinary peas or olives. The terms "half grown" and "full grown" also refer to the size of the developing nuts in the trees.

Methods of Determining the Extent of Control.—The extent of the control afforded by the different materials used was determined by: (1) comparing the count of diseased nuts in or under sprayed and un-

sprayed trees; (2) comparing the weight of crop from sprayed and unsprayed trees; (3) estimating the extent of control and determining the general effects of the treatments by making personal observations. None of these methods is without fault in determining the extent of disease control in any economic plant, and each is even more faulty when applied to walnuts. For this reason only control data that show the benefits of the spray without the necessity of resorting to statistical methods to prove the point are included in the tables. Wherever possible weights and counts were taken in the same orchard, and in virtually every instance the benefits afforded by the spray were sufficient to be readily apparent on sight alone. For a more complete discussion of the problems met with in determining the amount of control see "Difficulties Involved in Determining Control of Bacteriosis," page 51.

Quality, trade sizes, and grades were determined after the method of the California Walnut Growers Association.[18]

RESULTS OBTAINED EXPERIMENTALLY WITH SPRAYS

Even before the season was very far advanced, in the first year of the experiments, it was strikingly evident that control in varying amounts had been obtained with each of three copper-containing materials, namely, bordeaux, basic copper acetate, and ammoniacal copper carbonate. Bordeaux gave the best results of all, and after several years' trial the basic copper acetate and ammoniacal copper carbonate were dropped from the experiments. See "List of Chemicals and Spray Materials Tried with Doubtful, Limited, or Unfavorable Results," p. 77, for a further discussion of them.

Bordeaux 8–4–50 the Most Satisfactory Spray for Control of Bacteriosis.—Many bordeaux formulas, yielding acid, neutral, and excessively alkaline mixtures, were tried in the course of the experiments. The 8–4–50 formula proved superior to all others, and the control data presented in the tables of this paper were derived almost exclusively from experimental use of spray prepared with it. Weaker mixtures pre-

[18] To determine quality at least three random samples of 100 nuts each from each of the sprayed plots were measured and graded for size, also cracked and tested for color, condition of the kernels, etc., and an average taken of the lot. Measurement of sizes invariably was made with the special device used by inspectors of the Association.

The trade sizes are Large, Fancy, and Baby. Jumbo is an extra-large size no longer distinguished from Large by the California Walnut Growers Association.

The Diamond grade is the best pack of the California Walnut Growers Association. The second-grade pack is known as Emerald, and California is third. Since the qualifications of each grade have fluctuated somewhat in the past and may again in the future, no attempt is made here to define them. The grades are based, however, on the color, size, and condition of both shells and kernels.

pared with ingredients in this same ratio, even bordeaux 4–2–50, often showed distinct control value but were inferior to the stronger spray.

In the 8–4–50 formula the lime is cut to one-half the amount of bluestone used instead of the pound-for-pound ratio generally employed in making bordeaux spray. The amount of lime used is still distinctly in excess of the amount necessary to neutralize all of the bluestone, however. Several advantages are offered by this formula: the spray is distinctly alkaline, and alkaline bordeaux is less toxic or injurious in its action on tender walnut foliage than the acid or neutral mixture. The addition of more lime than that recommended in no way obviates spray burn of walnut foliage when climatic conditions are conducive to it. See "Spray Burn and Other Undesirable Effects," page 69. Bordeaux of the formula recommended also is of more gelatinous consistency and adheres better than one containing a greater excess of lime, and the spray residue left on the foliage is less opaque and impermeable to light—an important point. Finally its maximum benefits are probably obtained more quickly than when bordeaux with a greater excess of lime is used; certain bordeaux chemists are of the opinion that the greater the excess of lime present the slower the disinfectant action of the spray. No great excess of lime beyond the margin of safety for the average grower is contained in bordeaux 8–4–50. See "The Preparation of Bordeaux Spray," p. 71, for a simple method of preparing it.

The Pre-Bloom Spray.—Because the results first obtained in 1927 and substantiated experimentally every year thereafter clearly showed that the strategic period for securing the maximum control with any one spray is during the pre-bloom stage, attention is called to the fact that a pre-bloom spray invariably was given in each experiment recorded in the various tables and observational data that follow.

Control Obtained with Bordeaux 8–4–50 as Indicated by Counts.—In table 1, the figures represent the extent of control obtained with bordeaux 8–4–50 as indicated by count of diseased and healthy nuts in or under sprayed and unsprayed trees. In several of the orchards two or more applications of spray were given.

The counts of diseased nuts in sprayed and unsprayed trees as shown in table 1 indicate a striking control of the disease in most instances.

Control Obtained With One Application of Bordeaux 8–4–50 as Indicated by Weights.—In table 2 the control obtained with a single spray as indicated by a comparison of weight of crop from sprayed and unsprayed trees is shown. The spray was applied in the pre-bloom stage.

In each experiment cited in table 2 the sprayed and unsprayed plots were immediately contiguous, the trees were of the same size, age, and variety, and were subjected to similar growing conditions.

TABLE 1

THE EXTENT OF CONTROL INDICATED BY COUNTS OF DISEASED AND HEALTHY NUTS IN OR UNDER SPRAYED AND UNSPRAYED TREES

Grower	Year	Trees*			Treatment			Date of nut count	Total nuts counted	Location of the nuts when counted	Blighted nuts		
		Variety	Age	Number	Spray	Date	Size of nuts when sprayed				Total	Average per tree	Per cent
Bishop Ranch, Goleta, California	1930	Seedlings	Old	10	Bordeaux 8-4-50	Apr. 22 June 9†	Pre-bloom, Half-grown	Aug. 12	2,900	In trees	138	13.8	4.75
				10	Unsprayed	.....	.....	Aug. 12	3,563	In trees	1,618	161.8	45.43
C. E. Bainbridge, Kenwood, California	1928	Concord	14 yrs.	8	Bordeaux 8-4-50	.....	Pre-bloom stage	Late summer	Negligible	On ground	.....	Negligible or none	.....
				5	Unsprayed	.....	.....	Late summer	840	On ground	.....	168	.....
R. Forbis,‡ Lilley, Oregon	1929	Franquette	13 yrs.	24	Bordeaux 8-4-50	May 21	Pre-bloom stage	July 10	2,122	In trees	176	7.3	8.3
				23	Unsprayed	.....	.....	July 10	2,390	In trees	1,063	46.2	44.4
J. O. Holt,‡ Eugene, Oregon	1929	Franquette	18 yrs.	10	Bordeaux 8-4-50	May 21 June 21†	Pre-bloom stage Pea size	July	927	In trees	5	0.5	0.5
				10	Unsprayed	.....	.....	July	1,875	In trees	222	22.2	11.8

* The blocks of sprayed and unsprayed trees bracketed together were immediately adjacent to each other, of the same age and variety, and outside of the spray treatment subjected to conditions as identical as it was possible to secure.

† Second spray on same block.

‡ Data furnished by H. P. Barss of the Oregon State College, Corvallis, Oregon. Crop weights failed to substantiate the excellent controls indicated by the counts in these two orchards. See "Difficulties Involved in Determining Control of Bacteriosis," p. 51 for possible explanations.

TABLE 1—*(Concluded)*

Grower	Year	Trees*			Treatment			Date of nut count	Total nuts counted	Location of the nuts when counted	Blighted nuts		
		Variety	Age	Number	Spray	Date	Size of nuts when sprayed				Total	Average per tree	Per cent
Walter Stevens, San Jose, California	1930	Payne	10 yrs.	21	Bordeaux 8-4-50	March	Pre-bloom stage	July 11	.....	On ground	362	17	.....
						May †	Olive size						
				6	Unsprayed	.....	.....	July 11	.....	On ground	553	92	.....
Hunt Bros. Packing Corporation, Linden, California	1930	Payne	14 yrs.	7	Bordeaux 8-4-50	Mar. 27	Pre-bloom stage	July 1	.....	On ground	120	17	.....
						Apr. 20†	Post-bloom						
				7	Unsprayed	.....	.....	July 1	.....	On ground	1,350	236	.....
J. M. Colley, Santa Paula, California	1932	Seedlings	30 yrs.	7	Bordeaux 8-4-50	.....	Pre-bloom stage	Aug. 5	.....	On ground	477	80	.....
						.....	Olive size†						
				8	Unsprayed	.....	.....	Aug. 5	.....	On ground	2,677	335	.....
E. A. Smith, Concord, California	1932	Payne	9 yrs.	12	Bordeaux 6-3-50	Mar. 20	Pre-bloom stage	Late July	.....	On ground	1,031	85.9	.....
					Bordeaux 8-4-50†	May 8	Large olive size						
					Bordeaux 8-4-50¶	June 3	¾-grown						
				12	Unsprayed	.....	.....	Late July	.....	On ground	2,524	210.3	.....

* The blocks of sprayed and unsprayed trees bracketed together were immediately adjacent to each other, of the same age and variety, and outside of the spray treatment subjected to conditions as identical as it was possible to secure.

† Second spray on same block.

¶ Third spray on same block.

TABLE 2

THE EXTENT OF CONTROL OBTAINED WITH A PRE-BLOOM SPRAY OF BORDEAUX 8-4-50 AS INDICATED BY A COMPARISON OF THE NET WEIGHTS OF NUTS FROM SPRAYED AND UNSPRAYED TREES

Grower	Year	Trees*			Treatment	Total yield	Average yield per tree	Net gain per tree
		Variety	Age	Number		*lbs.*	*lbs.*	*lbs.*
Russel Rowe, Goleta, California	1930	Seedlings	Old	12	Bordeaux 8-4-50 +1½ per cent San Jose Summer Oil	1,644	137	38
				12	Unsprayed	1,183	99	
Bishop Ranch, Corona del Mar, Plot 1. Goleta, California	1929	Seedlings	Old	24	Bordeaux 8-4-50	4,054	169	23
				24	Unsprayed	3,492	146	
Bishop Ranch, Corona del Mar, Plot 2. Goleta, California	1929	Seedlings	Old	12	Bordeaux 8-4-50	1,182	99	19
				29	Unsprayed	958	80	
E. U. Leh, Concord, California	1930	Payne	5-year grafts on 10-year trees	25	Bordeaux 8-4-50	552	22	8
				25	Unsprayed	351	14	
Mrs. J. G. Miller, Linden, California	1929	Payne	Old	8	Acid bordeaux	720	90	26
				16	Unsprayed	1,020	64	
C. E. Bainbridge, Kenwood, California	1928	Concord	14 years	8	Bordeaux 8-4-50	488	61	20
				5	Unsprayed	205	41	
G. C. Bailey,† Wilbur, Oregon	1929	Franquette	19 years	17	Bordeaux 8-4-50	1,326	78	36
				17	Unsprayed	714	42	
Anderson-Barngrover Ranch Co. Orchard, Linden, California	1927	Payne	7-year grafts on 10-year trees	10	Bordeaux 8-4-50	227	23	6
				10	Unsprayed	169	17	
Bowman-Kuhn Ranch‡, San Jose, California	1930	Mayette	20 years	6	Bordeaux 8-4-50	570	95	42
				6	Unsprayed	318	53	
Raymond Miller‡ Linden, California	1931	Payne	16 years	5	Bordeaux 8-4-50	761	152	65
				5	Unsprayed	437	87	
Mrs. J. G. Miller,‡ Linden, California	1931	Payne	20 years	6	Bordeaux 8-4-50	827	138	40
				6	Unsprayed	588	98	

* The blocks of sprayed and unsprayed trees bracketed together were immediately adjacent to each other, of the same age and variety, and outside of the spray treatment subjected to conditions as identical as it was possible to secure.

† Data submitted by H. P. Barss, Oregon State College, Corvallis, Oregon.

‡ A large acreage was sprayed in this orchard with the same results indicated by the smaller number of trees in the table.

A comparison of crop weights from sprayed and unsprayed trees as shown in table 2 indicates a noteworthy control of the disease in most instances with one application of spray.

The acid bordeaux which gave the control listed in Mrs. Miller's orchard at Linden was applied experimentally by the writer. This type of bordeaux is further discussed under the heading, "List of Materials Tried with Limited, Doubtful, or Unfavorable Results," on page 77.

Control Obtained with Two Applications of Bordeaux 8–4–50 as Indicated by Weights.—In the preceding section the results obtained with a single spray applied during the pre-bloom stage are shown. In each case the control has been definite, in many instances striking.

In table 3 the cumulative effect of two sprays is shown. In each experiment two plots lying side by side received a spray during the pre-bloom stage. Later, as indicated in the table, one of the plots received a second application of the spray at the same strength. At harvest the yield of nuts from each sprayed plot was compared with that from an adjoining block of unsprayed trees. The beneficial effects derived from each individual application of spray are unmistakable.

In table 3 it may be noted that the first spray seemingly effected little control of the disease in Dr. Campbell's orchard. As a matter of fact the control afforded by the first spray was great. The beneficial effects of the first application were gradually lost in this plot, however, when no additional sprays were applied to protect the crop.

In table 4 additional figures are given which show the control obtained with two sprays. In each case the first spray was given in the pre-bloom stage and the second after the nuts had set. No attempt was made to determine the benefits of each individual spray as was done in the orchards cited in table 3.

Control Obtained with Multiple Sprays of Bordeaux 8–4–50.—An attempt was made to determine whether multiple sprays, namely, several applications of a given spray to the same trees, would effect a better control of bacteriosis than one spray alone. In table 3 the comparative benefits of one and two sprays are shown. Thus far it has been impossible to show in figures the additional value of a third or fourth spray in fighting the disease. This is because the requirements for obtaining comparable results in such an experiment are so exacting that it is practically impossible to find them in any one orchard. Fluctuation in the size and general health of the trees as well as in the size of the crop set at different parts of the orchard, the result of uncertain causes, likewise the irregularity with which the disease itself appears, complicate the problem of securing reliable figures to show the relative benefits afforded by more than two sprays. Yet observations made in the course of many experiments

TABLE 3

COMPARISON OF THE WEIGHTS OF NUTS FROM UNSPRAYED TREES, AND FROM TREES SPRAYED DURING THE PRE-BLOOM STAGE, AND FROM TREES SPRAYED TWICE INCLUDING THE FIRST SPRAY MENTIONED

Grower	Year	Trees*			Treatment		Total yield	Average yield per tree	Net gain per tree
		Variety	Age	Number	Spray	Time of application			
							pounds	*pounds*	*pounds*
Dr. E. O. Campbell, Goleta, California	1929	Seedlings	30 yrs.	12	Unsprayed	.....	472	39	....
				12	Bordeaux 8-4-50	Pre-bloom stage only	504	42	3
				12	Bordeaux 8-4-50	Pre-bloom stage and on June 1	712	59	20
Bishop Ranch, Glen Annie, Goleta, California	1930	Seedlings	Old	26	Unsprayed	.....	998	35	....
				9	Bordeaux 8-4-50	Pre-bloom stage only	470	52	17
				10	Bordeaux 8-4-50	Pre-bloom stage and on June 9	664	64	29
Bowman-Kuhn Ranch, San Jose, California	1929	Payne	Mature	6	Unsprayed	.....	384	64	....
				6	Bordeaux 8-4-50	Pre-bloom stage only	528	88	24
				6	Bordeaux 8-4-50	Pre-bloom stage and in July	600	100	36

* The blocks of sprayed and unsprayed trees bracketed together were immediately adjacent to each other, of the same age and variety, and outside of the spray treatment subjected to conditions as identical as it was possible to secure.

TABLE 4

COMPARISON OF THE WEIGHTS OF NUTS FROM UNSPRAYED TREES AND TREES SPRAYED TWICE, WITHOUT CONSIDERATION OF THE INDIVIDUAL BENEFITS AFFORDED BY EITHER SPRAY

Grower	Year	Trees*			Treatment		Total yield	Average yield per tree	Net gain per tree
		Variety	Age	Number	Spray	Time of application			
							pounds	*pounds*	*pounds*
Visalia Orchard Co., Visalia, California	1929	Payne	10 yrs.	19	Bordeaux 8-4-50	Pre-bloom and post-bloom stages	2,244	118	19
				19	Unsprayed	.....	1,885	99	....
Hunt Bros. Packing Corporation, Linden, California	1930	Payne	14 yrs.	7	Bordeaux 8-4-50	Pre-bloom and post-bloom stages	1,036	148	37
				6	Unsprayed	.....	664	111	....
Bishop Ranch, Corona del Mar, Goleta, California	1931	Seedlings	Old	23	Bordeaux 8-4-50	Pre-bloom and post-bloom stages	1,243	54	21
				19	Unsprayed	.....	623	33	....

* The blocks of sprayed and unsprayed trees bracketed together were immediately adjacent to each other, of the same age and variety, and outside of the spray treatment subjected to conditions as identical as it was possible to secure.

designed to show the value of multiple sprays frequently seemed to show that each additional application of spray given at the right time afforded a material reduction in the amount of the disease. In the Anderson-Barngrover Ranch Company's orchard at Linden where much work with multiple sprays was done, the relative control of bacteriosis afforded by three and four applications of bordeaux to the same trees appeared to be much greater than that afforded by one or two; there were fewer diseased nuts in or under trees receiving the benefits of numerous sprays than in or under those sprayed only once. The great fluctuation in the size and general condition of the trees, however, made it impossible to show this difference in figures of any kind.

Control Obtained With Bordeaux 8–4–50 as Indicated by Personal Observations.—The following data are almost wholly observational and not often supported by figures. Such data admittedly have the least value of all and have been used here only when striking in character. Much of the information has been presented by growers who were enthusiastic about the results obtained.

In 1928, Mr. D. Chisholm of Windsor, California, sprayed two long rows of old seedling walnut trees which line the entrance drive to his apple orchard with bordeaux 8–4–50 during the pre-bloom stage. Part of the trees were sprayed a second time with the same spray after the nuts had set. All of the trees had been severely attacked by bacteriosis year after year previous to the experiment. Scattered among the apple trees are walnut replants of various ages and sizes. These alone were left unsprayed. When the writer visited the orchard before harvest, the unsprayed trees were so severely attacked by the disease, that the crop was virtually destroyed in all of them. Under one unsprayed tree the entire crop lay rotting on the ground. All of the sprayed trees, on the other hand, bore a splendid crop.

The control was visibly greater in the trees sprayed twice than in those sprayed only once. Unfortunately neither weights nor counts were made. Mr. Chisholm enthusiastically expressed his satisfaction with the results obtained.

In 1928 and 1929, Mr. Donald Nye of Healdsburg, California, sprayed his sixteen or seventeen-year-old Franquette walnuts with bordeaux 8–4–50 during the pre-bloom stage. An average of only 10 gallons per tree was used, which is a very small quantity for trees of that age. At harvest when the nuts had been shaken down he examined all that lay in a straight strip under the trees. The results are shown in table 5. In 1928, Mr. Nye estimated the crop on the sprayed trees to be three times as great as that on unsprayed trees.

In 1929, Mr. Raymond Miller at Linden, California, sprayed a large block of Payne walnuts with bordeaux 8–4–50 during the pre-bloom stage. Mr. Miller's mother, Mrs. J. G. Miller, owns a similar orchard immediately across the Waterloo road from her son's. This orchard was not sprayed. Both orchards are about eighteen years of age. In late summer Mr. and Mrs. Miller sent for the writer to observe the extent to which

TABLE 5

Extent of Control Obtained in Mr. Donald Nye's Orchard at Healdsburg, California as Indicated by Counts

Year	Treatment	Total nuts counted	Per cent diseased
1928	Sprayed	500	2
	Unsprayed	500	28
1929	Sprayed	500	30
	Unsprayed	500	43

TABLE 6

Count of Diseased Nuts and Weight of Good Nuts from One Sprayed and One Unsprayed Tree Opposite Each Other in the Orchards Owned by Mrs. J. G. Miller and Mr. Raymond Miller

Treatment	Stage when treated	Count of diseased nuts on ground before harvest	Weight of good nuts harvested	Net gain in favor of spray
			pounds	*pounds*
Bordeaux 8-4-50+2 per cent Volck oil	Pre-bloom	9	167	77
Unsprayed		930	90	....

the disease had affected the crop in the two orchards. The ground under the unsprayed trees in Mrs. Miller's orchard was literally covered with blighted nuts, whereas under Mr. Miller's sprayed trees the number was negligible. Two trees, opposite each other, one in Mrs. Miller's orchard and the other in Mr. Miller's orchard were selected as representative of the situation in the two orchards. Counts of diseased nuts on the ground under each tree were made before harvest. The weight of crop from each tree was also taken. The results are shown in table 6.

In 1930, Mr. J. F. Treat, Jr., in charge of the Hunt Brothers Packing Company's walnut orchard at Linden, sprayed a block of Payne walnuts experimentally. On the way to the Payne trees, the spray rig was stopped to spray one fourteen-year-old Eureka tree in a row of 7 trees. The tree was sprayed first during the pre-bloom stage and again when the nuts

were about the size of peas and the flowers had faded. All trees in the row had been affected severely by the disease in previous years. The control obtained was striking. A count of the blighted nuts on the ground under the 6 unsprayed trees and 1 sprayed tree was made in July. Weights were taken at harvest. The results are shown in table 7.

TABLE 7

COUNT AND WEIGHT OF DISEASED AND HEALTHY NUTS FROM 1 SPRAYED AND 6 UNSPRAYED TREES IN THE HUNT BROTHERS PACKING COMPANY ORCHARD AT LINDEN, CALIFORNIA, IN 1930

Treatment	Stage when treated	Number of trees	Count of diseased nuts on ground		Weight of nuts harvested	
			Total	Average per tree	Total	Average per tree
					pounds	*pounds*
Bordeaux 8-4-50	Pre-bloom and post-bloom stages	1	21	21	253	253
Unsprayed		6	1,886	318	480	80

TABLE 8

ANNUAL YIELD OF NUTS IN POUNDS FROM 76 PAYNE WALNUT TREES IN THE HUNT BROTHERS ORCHARD PREVIOUS TO AND INCLUDING 1930, THE YEAR THEY WERE SPRAYED FOR THE FIRST TIME

Year	Treatment	Yield	Year	Treatment	Yield
		pounds			*pounds*
1923	Unsprayed	2,295	1927	Unsprayed	6,200
1924	Unsprayed	3,124	1928	Unsprayed	3,600
1925	Unsprayed	2,759	1929	Unsprayed	3,639
1926	Unsprayed	695	1930	*Sprayed*	*10,886*

In 1930 Mr. Treat also sprayed a block of 76 Payne walnuts in the Hunt Brothers Orchard for the first time. These trees were planted in 1916–1918. Bacteriosis had destroyed much of the crop year after year previous to the time the trees were sprayed: Before harvest, when the writer visited the orchard, there were very few blighted nuts either in the trees or on the ground. The weight of nuts taken at harvest, which practically tripled previous average yields from this block of trees, is shown in table 8. Mr. Treat kindly furnished the yields from the trees over a period of eight years.

It will be noted that with the single exception of the crop of 1927, no annual yield was more than a third as great as that the year the trees were sprayed. The year 1927 was the most favorable to walnut production ever recorded in California.

Mr. Arch Wilson of Cupertino, California, who owns an orchard of

mature walnut trees, reported that bacteriosis had always severely attacked his crop prior to his use of spray. In 1930 and 1931 he sprayed with bordeaux 8–4–50 with consequent increase in crop and reduction in the amount of disease. Rows left unsprayed for checks clearly showed more disease than those sprayed.

Mr. Frank Leib of San Jose made the following interesting statement after his use of bordeaux 8–4–50 to control bacteriosis: "Overloading of the sprayed trees caused the nuts to be less completely filled but not enough to reduce the grade. To the eye the sprayed trees appeared to have twice as many nuts as the unsprayed trees. Nuts from trees on Royal hybrid root (Bolivian cross) were uniformly well filled, however, and the kernels plump, in contrast to those from trees on California black root."

In general Mr. Leib believed the spray to have improved the quality of the nuts, orchard run; in one of his orchards previous to the year he started spraying he harvested 10½ tons net of good-grade nuts and 60 bags of Babies. The first year he sprayed he harvested 24½ tons net of good-grade nuts, and only 18 bags of Babies, from the same orchard.

In the orchard referred to above, Mr. Leib has numerous commercial varieties growing. He sprayed all during the pre-bloom stage. By the time he had finished spraying his late varieties, the young nuts in the earlier ones had already passed the pollination period and were ready for the second spray. All varieties were sprayed twice. The Leib and Leib, an excellent variety extensively raised by Leib, had been attacked with increasing severity by bacteriosis for some few years previous to the use of spray. The clearing-up of the disease in this variety during the past two years has been striking.

Mr. A. P. Freeman of Lawrence Station, California, has owned an orchard of Santa Barbara Soft Shell Seedlings for twenty-four years. His average annual loss of crop to bacteriosis previous to spraying had been at least 80 per cent. There were years when the entire crop was destroyed. Because of the severity of the disease Mr. Freeman long ago removed most of the orchard and planted the ground to other crops. In 1930 he was planning to remove the balance of his trees but decided to spray. He applied bordeaux 8–4–50 during the pre-bloom stage with excellent results. In 1931 he sprayed again, and the writer visited the orchard before harvest. Bacteriosis was virtually nonexistent in the heavily loaded trees. Mr. Freeman regarded his control for the two years as practically 100 per cent. Although no trees were left unsprayed for checks, the severe attack on the crop in orchards in the general vicinity clearly showed that conditions there had been favorable to bacteriosis both years.

Mr. Walter Stevens of San Jose in whose orchard counts were made (table 1) in 1930, sprayed again in 1931 with bordeaux 8–4–50. For check trees Mr. Stevens left unsprayed a number of walnut replants of the same variety in an adjoining prune orchard. Unfortunately the age and size of the unsprayed trees varied too greatly to permit of an accurate comparison of weights and counts. Some of the unsprayed trees were as large as the sprayed trees, others were smaller, but all set a heavy crop at the beginning of the season. Little disease developed in the sprayed trees throughout the season, whereas the crop in the unsprayed trees was severely attacked. Shortly before the harvest an inspection of this orchard showed the ground under the unsprayed trees to be covered with blighted nuts. About 75 per cent of the crop that remained on the trees was diseased. The number of rotten nuts under the sprayed trees was negligible. The crop on the trees was excellent and showed very little bacteriosis.

Mr. Charles Anderson, in charge of the Anderson Orchard Company's large Payne walnut orchard on Archerdale Road, Linden, California, reported a control of the disease by spraying in 1930 which increased the crop 15 per cent.

Mr. Joseph Conner, manager of the Santa Clara Walnut Growers Association packing-house, sprayed some of the earlier varieties in his large orchard near Santa Clara in 1931 with bordeaux 8–4–50 in the prebloom stage. He reported a loss of 50 per cent in the unsprayed trees due to bacteriosis, whereas the loss was negligible in those sprayed.

Among other growers who have sprayed and reported successful results, often with considerable enthusiasm, may be mentioned Mr. W. H. Ward of Morgan Hill, Mrs. Glen Allen of Santa Clara, Mr. Galen Richardson of Byron, Mr. O. L. Freisinn of Santa Rosa, and Mrs. A. M. Moore of Ventura, all in California.

DISCUSSION

The prime object of the experiments has been to determine at what time or stage in the annual growth cycle of the walnut, sprays might be expected to control bacteriosis. Data showing the successful results obtained with sprays have been presented in the preceding section. It has been upon the accumulation of such data, as well as the writer's personal observations and experience, that the spray schedule recommended later on in this paper is based. It hardly seems necessary in a paper of this kind to present the accumulation of data, unsuccessful in character, which was obtained along with the successful. Much of it was obtained, however, and some of it has been used throughout the paper when necessary to the proper presentation and interpretation of successful results.

Experimental data obtained over a period of six years seem sufficient to justify the conclusion that the pre-bloom spray is absolutely indispensable and that its omission is almost certain to result in failure. In only one year were the climatic conditions in the locality where the experiments were being conducted such that the omission of the pre-bloom spray was not accompanied by untoward results. Thus the circumstances under which this spray can be safely dropped from any spray schedule recur so infrequently that it would be very unwise to chance omitting it. While best results ordinarily were obtained when the first application of spray was given during the pre-bloom stage as defined on page 35, there were exceptions to this rule; occasionally excellent controls were obtained slightly earlier, namely, when the buds were merely swelling and very little new growth had appeared; or even a little later, namely, when the young nuts not only had appeared but when some of them already had reached the size of peas. Control at this late date was very exceptional, however, and it may be expected to occur only when the climatic conditions preceding the application of the spray have been distinctly dry and unfavorable to infection. Spray applied at this stage also may interfere with fertilization of the nuts.

It has been shown in table 2 that the control exerted by a pre-bloom spray may persist, in part at least, until harvest. It may be stated frankly, however, that such results were the exception rather than the rule. It seems unnecessary to present data showing how a single pre-bloom spray may fail to control walnut bacteriosis. The dictates of common sense and a simple knowledge of the disease with its very long infectious period make it clear that an adequate control with a single pre-bloom spray ordinarily must be the exception rather than the rule. Negative data bearing on this point also might be misinterpreted; it might reasonably be questioned whether the failure was traceable to the unsuitability of bordeaux as a disinfectant to control bacteriosis or simply to insufficient applications of the spray. Data from the Campbell orchard (table 3) were included purposely to prove the latter to be true.

It is impossible to state how long the protective action of any one application of spray will last. The strength of the spray, its method of preparation, the climatic conditions, and the rate of growth of the susceptible tissues very definitely influence this point.

In tables 3 and 4 the benefits afforded by two applications of spray have been shown. It is impossible to secure figures that prove irrefutably that a second spray applied immediately after the nuts have set will nearly always produce greater benefits than one applied late—a month later for instance. But the experimental data and personal observations

strongly indicate this to be a fact. There may be exceptions. The crop increase resulting from a second application of spray in July to trees in the Bowman-Kuhn orchard (table 3) was as great as that in the Bishop orchard which was sprayed for a second time at a much earlier date. But this alone cannot be interpreted as proof that long intervals between sprays lead to as good results as short ones. On the contrary the *relative* increase in the Bowman-Kuhn orchard was less owing to the delay than in other orchards sprayed earlier but in which the yields were smaller for reasons other than bacteriosis. The Bowman-Kuhn ranch is well known in the Santa Clara Valley for its heavy yields, and the year of the experiment the crop was extraordinarily large. In spite of heavy losses by bacteriosis a large amount of the crop had not yet contracted the disease at the time the second spray was applied and was protected by it. Abnormally damp weather later in the season rather than early greatly influenced the situation in the Bowman-Kuhn orchard also.

Climatic conditions vary somewhat from year to year. Occasionally the deviation from the normal is extreme; in an abnormally dry year a delay in the application of the second spray after the nuts have set may produce no unfavorable results. But since there is no way of knowing when such extremes may occur it would be folly to risk the delay.

As indicated in the preceding section it has not been possible to show with figures the relative value of a third or fourth application of spray to control bacteriosis. Observational data confirming their value is abundant, however. For instance, in 1929 the Visalia Orchard Company's orchard (table 4) was given a pre-bloom and a post-bloom spray. In June, before the abnormally late rainfall of that year took place, there was an almost perfect control of the disease in the very large crop in the sprayed trees. The number of blighted nuts either in or under the trees was negligible. The crop in the unsprayed trees left as checks was severely attacked, and the ground beneath was covered with rotten nuts. After the June rains bacteriosis quickly established itself in the sprayed trees, which at that time were without protection since the spray residue applied two months earlier had largely been dissipated or outgrown. By harvest much of the crop had been destroyed. A third spray applied before the June rains very likely would have prevented much of the infection that took place so late that year.

Ordinarily sprays applied as late as June will be of little value because under normal conditions the rainy season in California will have been passed and the disease automatically checked as a consequence. Evidence of the kind given seems to justify the recommendation of sufficient sprays during the wet season to give the crop adequate protection.

DIFFICULTIES INVOLVED IN DETERMINING CONTROL OF BACTERIOSIS

There is no single, simple, and exact method of determining the extent of control of bacteriosis obtained with sprays. Numerous obstacles are encountered for which due allowance must be made if the results secured are to be properly understood.

Outbreaks of bacteriosis occur only when all of a number of conditions are favorable, consequently its occurrence is very irregular from season to season. Similarly the severity of the attack in the same locality may vary from orchard to orchard and even within one orchard. Hard and fast conclusions for or against a given treatment cannot be drawn from figures taken at widely scattered points in the same orchard. Fluctuation in the general size of the trees, particularly in large blocks, further adds to the difficulty of demonstrating with simple figures the indubitable fact that two sprays may give better results than one, three better than two, etc.

In contradistinction to the apricot, peach, and many other economic crops, walnuts are never thinned to produce uniformity of size and quality. The custom is to leave any and all nuts on a tree that it can produce. Up to a certain point, which will vary greatly with the vigor of the tree, the available moisture, the general environmental conditions, etc., it will produce the superior quality demanded by the trade, but beyond the optimum quantity for that tree under its environmental conditions, the quality and size become increasingly less satisfactory. This situation becomes all the more complicated in seedling trees, no two of which are just alike in their yield characteristics; some are always shy bearers while others regularly produce huge crops. Some produce small sizes only. Still others produce kernels of inferior quality regardless of the environment. To crowd more nuts on such trees beyond their optimum simply means the lowering of an already low standard of size or quality or both to a point which is unsatisfactory from the standpoint of the trade. A single example will serve to illustrate the point: In one orchard the crop set in 1927 was excessive. At harvest the nuts were highly unsatisfactory; the size was small, the average run of the orchard consisting of 50 per cent Babies. Jumbos were absent and there were exceedingly few Large-sized nuts. The great bulk of the larger nuts was, rather, of merely a poor Fancy size. To make the Diamond grade with such a product necessitated the employment of extreme methods in the packing-house, namely, exceedingly careful sorting by hand and vacuum machine and finally blending the nuts with better ones from other or-

chards. The following year the crop in this same orchard was thinned by frost. At harvest the average size and quality of the nuts were exceptionally fine; a high percentage of Jumbos prevailed and the Large size constituted the bulk of the crop. Babies were almost totally absent. The kernels were well filled, and the entire orchard run was of Diamond grade.

Bacteriosis often acts like frost and may be a blessing in disguise when trees are overloaded or environmental conditions are unsuited to the production of large crops. Unfortunately the disease usually thins the crop too much. But to protect the crop on overloaded trees from bacteriosis by sprays simply means a crop of nuts of inferior size and quality at harvest. Some growers have erroneously attributed such inferiority to poisonous effects of the spray. When not loaded beyond their optimum, sprayed trees produce nuts of satisfactory size and quality.

Weights Alone of Good Nuts Do Not Tell the Extent of Control.—Trees sprayed with bordeaux may present an unmistakably larger crop to the eye than those not sprayed and yet at harvest produce a very disappointing weight of nuts. In some instances no gain by weight will have been made at all. A careful measurement of the sizes and a crack test frequently will tell that part of the story not revealed by the weights; the extra nuts are there, but they are smaller in size, and perhaps inferior in quality also, as a result of overloading the trees. In certain tests made, sprayed trees yielded twice as many Babies and distinctly fewer Large nuts than unsprayed trees with crop thinned by bacteriosis.

It is when the disease proves particularly severe and cuts the crop badly on the unsprayed trees that the weight of the crop on sprayed trees, regardless of the size or quality of the nuts, may and frequently does show the real protective value of the spray. Figures covering such unmistakable control by weight are given in tables 2 and 3 (pages 40 and 42, respectively).

Counts Alone of Diseased Nuts Do Not Tell the Extent of Control.—Counts made of diseased nuts in or under sprayed and unsprayed trees may be very misleading when unsupported by other data.

It is easy to count the diseased nuts lying on the ground, less easy to count them while they are still hanging in the trees, because they are not so easy to see and many may be overlooked, thus leading to incorrect conclusions.

When the count of diseased nuts lying on the ground under unsprayed trees or hanging in them is vastly greater than that made in or under sprayed trees, as is often the case, there can be no doubt as to the

protective value of the spray. The difference in the weights of the crop will usually substantiate the proof obtained with counts.

At times, however, the weight of crop from sprayed and unsprayed trees may not show the great difference that the count of diseased nuts in or under the trees seemed to forecast. This puzzling fact may be explained in part on the grounds that severe infection of the crop may have taken place after the count was made and much of the crop destroyed. A count merely indicates the amount of disease visible at the time it is made. In 1929, for example, the loss in the Linden area was largely due to late infections which followed one of the wettest Junes ever recorded there by the United States Weather Bureau. Counts made in one orchard before the rains showed little disease in either the sprayed or unsprayed trees, but counts made after the rains showed a severe infection of the unsprayed nuts. At harvest results were considerably different than anticipated on the basis of counts made before the rains.

Most counts of diseased nuts are made only after they are large enough to be discerned readily on the ground or recognized in the trees. Such counts cannot and do not reveal the loss of very small nuts early in the season.

Theoretically the loss of very small nuts affected with the disease should be less from sprayed trees than from unsprayed. Accordingly it is reasonable to suppose that the weight of good nuts at harvest from sprayed trees would be even greater than percentage estimates based on counts made fairly late in the season would seem to forecast. Actually this seldom proves true; the factor of overloading usually enters and causes the nuts to be smaller and less filled so that there is ordinarily no more gain in weight than the counts would indicate. On the other hand, unsprayed trees with crop materially thinned by the disease early in the season may and frequently do produce larger and heavier nuts and as a consequence may yield almost as much by weight as sprayed trees. But if the disease has been very severe in the unsprayed trees the high count of diseased nuts will indicate a loss that will also show in the weights regardless of size or quality.

If large canvases were placed upon the ground under the sprayed and unsprayed trees at the very beginning of the season and counts of the diseased nuts that fell made at short intervals until harvest, a more accurate estimate of losses could be made. The difficulties involved make such an experiment impractical. Similarly, if all the healthy and diseased nuts in the sprayed and unsprayed trees were counted, the exact percentage of loss due to the disease could be determined, but the job would be an exceedingly laborious one.

Counting the diseased and healthy nuts in certain areas or at certain levels in the trees or on a given number of limbs is apt to lead to incorrect conclusions unless the work is done on a very large scale, because the disease often appears unevenly in the trees; it is usually worse at the lower, damper levels and on the north or cooler sides of the tree, but not always.

It is not always easy to secure satisfactory weights and counts in the same orchard; the method of irrigating orchards often precludes making accurate counts of the diseased nuts on the ground, as does the presence of weeds in orchards left uncultivated until harvest. In table 9, however, may be seen a striking control based on weights and counts in old seedling trees. Counts were made of all diseased and healthy nuts hanging in the trees which could be seen clearly within 15 feet of the ground. The plots were immediately adjacent to each other.

TABLE 9

COUNTS AND WEIGHTS OF DISEASED AND HEALTHY NUTS FROM THE SAME PLOTS OF SPRAYED AND UNSPRAYED TREES AT THE BISHOP RANCH, GOLETA, CALIFORNIA, IN 1930

Control as shown by counts

Treatment	Number of trees in plot	Total nuts counted	Number of diseased nuts	Per cent of diseased nuts
Sprayed	10	2,900	138	4.75
Unsprayed*	10	3,563	1,618	45.41

Control as shown by weights

Treatment	Number of trees in plot	Total yield good nuts	Average yield per tree, good nuts
		pounds	*pounds*
Sprayed	10	644	64.4
Unsprayed*	26†	988	34.5

* The unsprayed trees not only were larger than the sprayed trees but were in a better physical condition, having less heart rot, dieback, etc., thus throwing the burden of proof sharply on the figures obtained with the spray. The plots were immediately contiguous.

† Whereas the weight of the crop was taken from the 26 unsprayed trees, counts were made in only 10 of these same trees. To make counts carefully is a slow process and the smaller number of trees, typical of the block, was considered sufficient.

Similar results may be noted in tables 1, 2, and 3, which contain counts and weights, some of which were compiled in the same orchards.

There are other serious obstacles to a correct determination of crop yields on the basis of counts of diseased nuts alone; sprays applied at the wrong time may interfere with pollination and cause a heavy drop of the young nuts. Similarly improperly made spray may burn the nuts and cause many of them to fall. Trees with crop thinned as the result of either

or both may show very little disease indeed when counts are made, and yet at harvest yield a weight of nuts that is very disappointing. For instance a count of several thousand nuts made in unsprayed trees may show 20 per cent to be diseased. A similar count in sprayed trees may show only 10 per cent. But if 15 per cent of the crop was destroyed at the beginning of the season on the sprayed trees as the result of spray burn or interference with pollination by the spray, then the weights of crop at harvest may be less than that from the unsprayed trees in spite of the control of the disease. Examples can be given: In Oregon the orchards of R. Forbis at Dilley and J. O. Holt at Eugene showed a noteworthy control of the disease on the basis of counts alone (see table 1, p. 38). At harvest, however, the average yield per tree by weight was very much less than that from unsprayed trees. In the Holt orchard the sprayed trees averaged only 22 pounds, the unsprayed 41 pounds. The trees were sprayed twice, the second spray having been applied when the nuts were about the size of peas, a stage now known to coincide roughly with the period of fertilization. The spray also severely burned the trees according to H. P. Barss, who cooperated in this experiment. In the writer's opinion the apparent control of the disease indicated by counts and the loss of crop indicated by weights may be explained on the basis of spray burn or the interference with pollination by the spray, or both. Very serious spray burn also was reported in the Forbis orchard, which may have been responsible for the similar situation there.

In 1929 certain blocks of seventeen-year-old Payne walnut trees in the Anderson Orchard Company's orchard at Linden were sprayed experimentally during the pollination period. A heavy drop of small nuts followed. The remaining nuts developed very little disease. In midsummer the count of diseased nuts under the sprayed trees averaged 24, under the unsprayed trees 300. Mr. Charles Anderson, in charge of the orchard, made a count at a different period and found 500 diseased nuts under one unsprayed tree, 8 under an adjoining sprayed tree. At harvest, however, the sprayed trees yielded a smaller crop by weight than the unsprayed trees in spite of the severe attack of the disease in the latter. Interference with fertilization by the spray applied at the wrong time and consequent heavy drop of nuts is the probable explanation of the results obtained.

A crack test of the crop thinned by spray may show a distinctly improved size and quality. This was true in the Anderson orchard just referred to where the unsprayed trees were overloaded to begin with and not appreciably thinned by the disease until late in the season. Thus the nuts lost by spray injury may have been numerically greater than indicated by weight alone.

Weights of nuts from sprayed and unsprayed trees are concerned with quantity and tell little or nothing about the quality. Counts on the other hand are very untrustworthy as an index of quantity, but in making them a clue often may be revealed as to what the quality of the nuts will be; nuts infected very late usually are not destroyed, but they do not often escape being shell-stained, and stain throws them at once into culls, the lowest-priced merchandise. A count of the spotted nuts made late in the season will give some idea as to whether much of the crop will be shell-stained or not. For instance in the Anderson Orchard Com-

TABLE 10

YIELD OF SHELLED-STAINED NUTS FROM SPRAYED AND UNSPRAYED TREES IN THE ANDERSON ORCHARD COMPANY'S ORCHARD AT LINDEN, IN 1929

Treatment	Number of trees in plot	Total nuts harvested in plot	Weight of shell-stained nuts		
			Total in plot	Average yield per tree	
				Wet weight	Dry weight
		pounds	*pounds*	*pounds*	*pounds*
Unsprayed	11	1,867	255	23+	18½
Sprayed	28	4,268	85	3	2½

pany's orchard just referred to where the weight of nuts from unsprayed trees exceeded that of the sprayed it took four men working at top speed to pick the shell-stained nuts from the belt as they came through the vacuum machine and huller. It was one lazy-man's job to pick the few shell-stained nuts from the sprayed plot when they came through. Table 10 gives the figures obtained in the experiment.

In table 10 an allowance of 20 per cent for shrinkage in dehydrating has been made. Shell-stained nuts averaged 16 pounds per tree less in the sprayed plot than in the unsprayed. Shell-stained walnuts were worth 8 cents a pound that year at the cracking plant of the California Walnut Growers Association. The 16 pounds therefore were worth only $1.28. If they had been protected against the disease they would have brought about 20 cents a pound,[19] which was the average price for good Payne nuts, orchard run in that year, or $3.20 for the 16 pounds. Thus, there was a loss of $1.92 a tree due to stained shells alone. It cost between 70 and 80 cents a tree to make and apply the spray. A net gain of $1.12 to $1.22 a tree could have been realized on the basis of reduction of shell-staining alone.

[19] The prices for Payne walnuts, orchard run, for 1931 and 1932, which are the lowest ever set by the Association for this variety, would be less than the 20 cents average given above. Incidentally the culls would be worth less also.

Control Estimates Based Upon Personal Observations Are Not Always Reliable.—Control estimates made by merely looking at the trees are very untrustworthy when unsupported by other data such as weights and counts.

Only when the control of bacteriosis in sprayed trees is extreme can one be reasonably sure that it has occurred at all or that proof will be found in increased weights at harvest. An increase in numbers is more apparent to the eye than the slight decrease in size of the nuts and plumpness of the kernels which frequently result when trees are overloaded, factors which may influence the weights unfavorably.

On the other hand weights taken at harvest may reveal a certain amount of control by spray not appreciable to the eye when the crop is on the trees.

COST AND PROFIT OF SPRAYING

In tables 2, 3, 4, 6, and 7 the net gain in weight of nuts obtained by spraying has been shown. The question at once arises as to how much it costs for materials, labor, etc., to get the nuts. In short, does it pay to spray?

Bordeaux 8–4–50 is made of bluestone, lime, and water. Its preparation is discussed further on page 71. The prices of bluestone and lime fluctuate both with the year and with the locality in which it is purchased; they are higher in some years and in some localities than in others. Bluestone costs from 6 to 6¾ cents a pound in barrel lots (552 pounds). Good lime may be had from ½ to 2 cents a pound in barrel lots (180 pounds). One gallon of bordeaux 8–4–50 at top prices costs a little more than 1 cent.

The cost of applying the spray varies greatly. It is cheaper in the long run to own one's spray equipment, particularly if the orchard is a large one. It is absolutely imperative to get the spray on at the right time if the best results are to be obtained. This is not always possible when the spray equipment must be rented. The prices charged by professional sprayers who furnish all necessary equipment and labor but not the spray material vary greatly according to the requirements of the work and the way the contract is drawn up. Ordinarily it costs from ¾ to 1½ cents a gallon to have the spray applied. These prices naturally include the sprayer's profit.

For average working purposes the writer estimates the cost of materials at 1 cent a gallon and the cost of applying the spray at 1 cent a gallon, or a total of 2 cents for each gallon of spray applied.[20]

[20] The average prices quoted above for labor and raw materials are considerably higher than those prevailing in 1931, 1932, and 1933. Bluestone could be had in large lots in some localities in 1932 and 1933 for one-half the price given above. The cost of a gallon of spray was less than 1 cent in 1931 and still less in 1932 and 1933.

The Amount of Spray Needed.—All parts of the tree must be thoroughly drenched with the spray. A mist or light fog which merely dampens the twigs and nuts will not do. A tree may be considered well sprayed only when all parts of it, inside and out, including the wood, foliage, and nuts, shine mirror-like in the sunlight. Unsprayed portions of the tree have a dull appearance in contrast. Excess spray that runs off is wasted.

Typical Examples of Spray Costs and Profits.—In table 11 typical examples of spray costs and profits realized by individual growers of

TABLE 11

COST AND PROFIT OF SPRAYING IN INDIVIDUAL ORCHARDS

Orchard	Year	Complete data in table No.	Number of applications of spray given	Total spray applied per tree		Increase in yield per tree		Net gain per tree from spraying
				Amount	Cost	Weight	Value	
				gallons	*dollars*	*pounds*	*dollars*	*dollars*
Bainbridge	1928	1, 2	1	15	0.30	20	4.00	3.70
Visalia Orchard Company	1929	4	2	40	0.80	19	3.80	3.00
Anderson-Barngrover Ranch Company Orchard	1927	2	1	10	0.20	6	1.20	1.00
J. G. Miller	1929	2	1	25	0.50	20	4.00	3.50
J. G. Miller	1930	....	1	30	0.60	33	6.60	6.00
Bowman-Kuhn Orchard	1929	3	1	....	0.36	24	4.80	4.44
			2	....	1.26	36	7.20	5.94

Payne and Concord walnuts are given. Profits have been computed on a basis of 20 cents per pound, orchard run, for good nuts of these varieties.[21] Cost of the spray has been estimated on a basis of 2 cents per gallon applied.

Mr. R. E. Barrett, entomologist of the Saticoy Walnut Growers Association, has submitted additional cost and profit data which he secured experimentally in three different orchards in Ventura County, California, in 1932. See table 12. Cost of making and applying the spray was 1¾ cents a gallon. Profits have been computed on a basis of 10 cents a pound for the walnuts, orchard run.

In a third orchard Mr. Barrett secured additional cost and profit data. See table 13.

The net profits indicated in tables 11, 12, and 13 are real or absolute only as far as the size and quality of the nuts were not impaired as the result of increasing the crop. An increase in quantity to the point of

[21] This estimate furnished by officials of the California Walnut Growers Association is the average price of a great many years. The price may be expected to fluctuate in individual years. In 1931 it was lower than the average, in 1932 still lower.

TABLE 12

DATA ON COST AND PROFIT OF EXPERIMENTAL SPRAYING SECURED BY R. E. BARRETT, ENTOMOLOGIST FOR THE SATICOY WALNUT GROWERS ASSOCIATION, VENTURA COUNTY, CALIFORNIA, IN 1932

Orchard	Trees			Treatment		Nuts produced			Total increase in yield, good nuts	Average increase yield per tree	Gross value of extra nuts	Gross gain per tree	Cost of spray per tree	Net gain per tree
	Variety	Age	Number	Spray	When applied	Total nuts	Good nuts	Blighted nuts						
						pounds	*pounds*	*pounds*	*pounds*	*pounds*	*dollars*	*dollars*	*dollars*	*dollars*
1	Wasson buds	10 yrs.	98	Bordeaux 8-4-50	Pre-bloom and post-bloom stages	7,224	6,998	226	461	4.7	46.10	0.47	0.23	0.24
			98	Unsprayed	.....	7,019	6,537	482	.....	.....	.....	.....	.....	.....
2	Placentia buds	9 yrs.	36	Bordeaux 8-4-50	Pre-bloom and post-bloom stages	2,737	2,685	52	588	16.33	58.80	1.63	0.23	1.40
			36	Unsprayed	.....	2,206	2,097	109	.....	.....	.....	.....	.....	.....

overloading the trees will result in decreased sizes and even decreased quality of the entire crop on the tree. Therefore an increase in quantity with no decrease in size or quality of the nuts may alone be considered

TABLE 13

ADDITIONAL COST AND PROFIT DATA SECURED BY R. E. BARRETT IN AN ORCHARD IN VENTURA COUNTY, CALIFORNIA, IN 1932

Trees			Treatment		Total yield	Average yield per tree	Increase in yield per tree		Cost of spray per tree	Net gain per tree as result of spray
Variety	Age	Number	Spray	Stage of trees when applied			Weight	Value		
					pounds	*pounds*	*pounds*	*dollars*	*dollars*	*dollars*
Placentia	21 years	301	Bordeaux 8-4-50	Pre-bloom and post-bloom stage	52,830	175 52	24.77	2.48	1 20	1 28
		24	Unsprayed	.....	3,618	150.75	.....	.....	.....	.....

TABLE 14

LOSS SUSTAINED IN 1930 IN THE SEEDLING ORCHARD BELONGING TO RUSSELL ROWE, GOLETA, CALIFORNIA, AS THE RESULT OF IMPAIRMENT OF NUT SIZES OWING TO THE CONTROL OF BACTERIOSIS WHICH CAUSED THE TREES TO BE OVERLOADED*

Treatment	Nut yields, sizes, and values						Cost of spray per tree applied	Net loss per tree as result of spraying
	Grade sizes†	Per cent of crop‡	Pounds	Opening price of seedling nuts per pound in 1930§	Value of the nuts at 1930 prices	Gross gain per tree as result of spray		
				dollars	*dollars*	*dollars*	*dollars*	*dollars*
Sprayed¶	Baby	14%	19.636	0.15	2.95	0.65	1.10	0.35
	Fancy	25%	34.935	0.23	26.99			
	Large	38%	52.516					
	Jumbo	21%	29.907					
Unsprayed	Baby	7%	7.751	0.15	1.16	.....	.....	.....
	Fancy	15%	15.179	0.23	20.99	.....	.....	.....
	Large	32%	32.339					
	Jumbo	44%	43.724					

* For complete conditions of the experiment see table 2, p. 40.

† Seedling walnuts are graded according to size merely as Large and Baby. They have been graded here as if they were a fancy budded variety merely to show the great fluctuation in sizes of nuts from sprayed and from unsprayed trees.

‡ The average of six crack tests is given.

§ Large-sized seedling nuts may be packed as Diamond or Emerald according to the quality. In this experiment the Large-sized nuts from both the sprayed and unsprayed trees were Diamond and worth 23 cents per pound that year. The Babies were worth 15 cents.

¶ The oil combined with the bordeaux cannot be held responsible for the reduction in nut sizes. A considerable accumulation of data reserved for another paper shows that oil such as was used in this experiment usually tends to stimulate the production of large-sized nuts.

an absolute net gain. In table 14 the undesirable effect on nut sizes and values that may result when trees become overloaded as the result of controlling bacteriosis is shown. While the example is extreme it clearly illustrates the truth of the statement just made.

HOW TO SPRAY TO CONTROL BACTERIOSIS

Because walnuts are grown in California under widely diversified climatic conditions, any spray schedule proposed for the control of bacteriosis should be broadly applicable to the state as a whole and at the same time sufficiently flexible to permit of easy adaptation to the peculiarities of each individual locality. The problems of the damp coastal regions of northern and central California are considerably different from those met with in the drier portions of the great Sacramento and San Joaquin valleys or in the arid interior counties of southern California.

Even the strength of the spray is subject to considerable change. For the state as a whole, bordeaux 8–4–50, which may be regarded as full strength, is recommended. For its preparation see page 71. Experimentally the writer has obtained good control at times with spray at half this strength, namely, bordeaux 4–2–50, but several growers have reported unsatisfactory results with it. Since the stronger mixture has consistently given the best results over a period of years the general recommendation is for the stronger spray. There is no point, however, in using the spray at full strength if a weaker and cheaper mixture will meet the requirements of the control consistently and regularly year after year in any given variety or in any particular locality. The grower who has had no especial difficulty in controlling the disease with bordeaux 8–4–50 might try a few tanks of weaker spray in an experimental way. The weaker spray should be used alongside of the mixture at full strength under similar conditions and the results compared. Whatever the reduction in strength, the same 2 to 1 ratio between the bluestone and the lime should be observed; for instance, 6–3–50 or 4–2–50. No attempt to secure results with weaker mixtures should be made in advance of trials with the spray at full strength.

It is impossible to state the exact number of applications of spray necessary to guarantee a satisfactory or practical control of the disease in any one year or in any one locality, but at least two must be considered the minimum as a general recommendation. These may be insufficient in very damp regions or in years of greater rainfall in those regions normally dry. Many instances of striking control obtained with only one spray have been observed. Satisfactory control, however, with one application of spray must be regarded as the exception rather than the rule. There may be years when even two, three, or more sprays may fail to give the practical control sought for, although each additional application will help. Analogous examples are found in other well-known dis-



Fig. 14.—The pre-bloom stage in the development of the new growth when the first spray must be applied for best results in controlling bacteriosis. (Natural size.)

eases such as pear scab, *Coryneum* blight of peach and apricot, etc., which stubbornly resist control in spite of many applications of spray when climatic conditions are particularly favorable to their development.

The following general recommendations are based upon the personal observations of the writer and experimental data obtained at widely separated localities in California.

Winter Sprays.—The disease cannot attack mature or old wood, therefore it is unnecessary to protect it with winter or dormant sprays. The new growth (including the foliage and nuts) alone is susceptible. Sprays applied in midwinter largely will have lost their strength or disappeared by the time the new growth which needs protection breaks the bud.

The First Spray.—The first application of bordeaux 8–4–50 should be given in the spring when the buds are expanding and some of the new growth has developed but when few or none of the nuts have appeared. See figure 14. This is the strategic period for securing the maximum results with any one application of spray. This spray, which has been given the name of "pre-bloom spray," is absolutely indispensable, and it must not be omitted under any conditions in any part of the state or in any year, if spraying is to be done at all for blight. It is a clean-up spray that disinfects the trees, covers over the lesions which have been exuding the living parasites during the rainy winter months, and destroys any great accumulation of the latter on the buds and in more protected parts of the trees. Subsequent sprays are valuable, but each must be regarded merely as an auxiliary or helper to the first one.

To delay the application of the first spray beyond the general period described may result in a severe loss, particularly if many of the young nuts have become visible. The young nuts are exceedingly susceptible and may become infected as soon as they appear if climatic conditions are favorable. Incidentally the time it takes the nuts to develop to a point where they are ready for fertilization after their first appearance is very brief indeed. In some varieties the flower lobes actually are already expanded and receptive to pollination when the nuts are first exposed. Spray residue on exposed flowers may easily prevent fertilization and result in loss of the nuts. Hence the urgent need of a sufficiently early clean-up spray in the trees so that the nuts may be produced under conditions as disease-free as possible and without the risk of interference with their fertilization. See figure 15.

If the orchard is large and the spray equipment too limited to permit of spraying all the trees during the critical period mentioned, or if weather forecasts indicate that the weather will be stormy, then it is ad-



Fig. 15.—English walnut flowers in bloom. It is dangerous to spray at this stage of the development of the nuts because of the possible interference with pollination by the spray. (Natural size.)

visable to start spraying a little earlier than usual to insure the completion of the job on time. In general to meet emergencies it is better by far to spray just a little too soon than just a little too late.

If the orchard consists of seedling trees, which characteristically do not start growth activities in spring as a unit, the first application should be made when a few of the earliest trees have reached the pre-bloom



Fig. 16.—Young nuts of the English walnut after they have been pollinized. The dead flower parts are still visible. In some instances the fertilized fruit may be smaller or larger than that shown here. The second spray should be applied just as soon as the flowers have faded regardless of the size of the fruit. (Natural size.)

stage. Poor control will result in most years if spraying is delayed until the latest trees have reached this stage; the crop on the earliest ones may become badly infected while the grower is waiting for all of them to reach the proper stage for spraying. Best results will be obtained if the owners of seedling groves can apply the pre-bloom spray at intervals as the trees reach the proper condition for spraying. This will entail the expenditure of extra time and money, however.

The first spray should be applied when the vegetative or fruit buds have reached the critical stage described without consideration of the catkin development during this same period, because the time of catkin production varies greatly with the variety as well as with the season.

The Second Spray.—A second application of spray at full strength should be made as soon as possible after the fertilization period has passed. Figure 15 shows young nuts with flowers in bloom, the critical period in their development, when sprays must be withheld. Not until the bulk of the flowers have faded and turned brown is it advisable to spray the trees again.[22] At this time the nuts will vary in size from a pea to a small olive, according to the variety. See figure 16. The problem presented by the second set of nuts which ordinarily may be expected complicates the situation considerably, but it will be necessary to concentrate attention on the first set, which usually is the largest. This is particularly true if the weather has been wet. To delay because the second set of nuts is still receptive to pollination may mean an attack of disease that will occasion the loss of more nuts than the second set would ordinarily produce.

The second spray, like the first, is practically indispensable. Whereas the first spray disinfects and cleans up the trees, the second spray is the first to coat the young nuts with a layer of protective poison and give them individual protection. The tendency of most growers is to wait too long before applying the second spray.

The Third Spray.—Whether a third spray will be required will depend on the locality or the climatic conditions that prevail at the time. If the weather remains damp and there is much fog and rainfall it may be necessary to spray again, particularly if bacteriosis has started to appear and apparently is making headway. It should be remembered that from nine days to several weeks may elapse between the time the initial infection takes place and the time the spot first becomes visible. Consequently there may be many more diseased nuts in a tree than can be seen at any one time. Likewise it should be remembered that neither the spray nor its effects last indefinitely; the residue is constantly being shaken and washed off, and what little remains steadily loses its strength. Also as the nuts expand in size they grow away from the spray residue upon them, exposing new susceptible surface all the time. To hesitate about applying a third spray may mean a loss of much of the beneficial results obtained with the first two.

Most orchards are irrigated in late May or early June for the first time. Almost invariably there is a flare-up of bacteriosis after irrigations. The application of water to the trees causes the lesions on the nuts

[22] In a personal conversation with the writer Mr. Milo N. Wood of the United States Department of Agriculture, who has made intensive studies of walnut pollination, expressed the opinion that as long as any portion of the flower remains green there is still a chance for fertilization of the nut to take place if it has not done so already. Ordinarily the number of nuts fertilized after the flowers have faded perceptibly is not great, however.

and shoots to ooze a black slimy sap that is swarming with the disease-producing bacteria. It collects in drops and spatters down onto healthy nuts below (fig. 8, page 20). Insects also track it about. Probably many of the late infections can be traced to this source. If a third or another spray is considered advisable it should precede rather than follow the irrigation. It will be some little time after irrigation before the ground will be firm enough to bear the weight of a spray rig, and much infection may take place in the interim. By spraying just before irrigation all new as well as old susceptible surfaces will be given a fresh coating of protective material that will enable the nuts to withstand the effects of the irrigation better.

For practical purposes, regardless of whether irrigation is practiced or not, the third spray should be applied when the nuts average ½ to 1 inch in diameter. It should be kept in mind that there is a greater possibility that infection will take place while the season is damp and the nuts still small, than later, when it is dry and the nuts are larger.

There is no objection to using as many sprays as may be necessary to control the disease. Whether it will pay to spray two, three, or more times will depend upon the size of the crop, the value of the nuts, etc. If the crop set is small it may not pay to spray more than once. On the other hand the beneficial effects obtained may be lost if adequate protection to the crop is not given later on. The individual grower must solve this problem for himself. See "Cost and Profit of Spraying," page 57.

The Cumulative Effect of Sprays.—There seems to be a cumulative control produced by sprays applied to the same trees year after year; already certain growers who have been spraying regularly for four and five years have noted a marked annual decrease in the amount of bacteriosis in their orchards. It does not stand to reason that such a disease can be wiped out in one year once it has become firmly established, but time may show, as it has already shown in cases of other serious diseases, that persistent and correct spraying may gradually reduce its incidence to a point where costly multiple-spray methods no longer will be necessary and the disease will be held in check with a single spray.

REASONS WHY SPRAYING MAY FAIL

Many growers not wholly familiar with the details of bacteriosis frequently associate other walnut troubles, either vague or definite, with it that have no connection whatever. Since the spray schedule devised for the control of bacteriosis cannot possibly prevent or remedy these troubles it may be well to mention them. First, spraying will not bring about an increase in the natural set of nuts on the tree. It merely pro-

tects those set by nature itself. Spraying will not make light kernels out of "ambers" or prevent the light kernels from turning dark. Darkening of the kernels is occasioned largely by delays in harvesting, unfavorable climatic conditions, etc. Bordeaux can neither make plump kernels out of shriveled ones nor prevent the kernels from becoming shriveled. Inferior quality of this sort frequently is traceable to insufficient irrigation, sunburn, etc. Similarly bordeaux cannot be relied upon to increase the size of the nuts, although some growers believe they have seen evidences of its having done so. Spraying will not prevent moldiness of the shells or of the kernels of nuts which have lain on damp ground or which have become moldy in the husks while waiting to be gathered. The use of bordeaux is designed primarily to prevent, not cure, bacteriosis. No spray can cure the disease already established in the nuts, twigs, or leaves.

The following discussion is pertinent only to bacteriosis and its control.

Careless Spraying Leads to Poor Results.—Unless the entire surface of susceptible tissue is thoroughly coated with spray it is possible for it to become infected. It will pay the grower, therefore, to make every effort to spray his trees as thoroughly as possible. See "The Amount of Spray Needed," page 58, and "The Cost and Profit of Spraying," page 57, for further information on this subject.

Too Few Applications of Spray May Lead to Failure.—A typical example of failure to control bacteriosis satisfactorily as the result of the use of an insufficient number of sprayings may be seen in results obtained experimentally in the Campbell Orchard at Goleta (table 3, page 42), where the excellent control afforded by the first spray was lost in one block of trees when no additional sprays were applied. Trees sprayed twice in this orchard yielded an increase in crop that more than paid for both sprays, whereas those sprayed once did not produce enough extra nuts to pay for the single spray.

Delay in Application of the Sprays May Lessen Their Value.—In table 3, page 42, and table 4, page 43, examples of striking control with two sprays are shown. However, in certain instances, even better results could have been had if the second spray had been applied earlier than it was. In one or two cases the second spray was not applied until the disease had reached epidemic proportions.

Estimates of the amount of infection in the trees based upon the amount of disease that is visible are untrustworthy. In addition to the nuts actually showing the disease there may be many more that are already infected but which will not develop lesions for some time to come.

The tendency on the part of growers is to hesitate about making a second or third application of spray largely for financial reasons. Their viewpoint is not difficult to appreciate, but unless bacteriosis is kept under constant vigilance and the trees protected properly with sprays applied at the right time, the money spent will not bring satisfactory returns.

Sprays Too Weak in Strength May Fail to Produce Satisfactory Results.—The advisability of using weak spray mixtures is discussed under the heading "How to Spray to Control Bacteriosis," page 61.

SPRAY DAMAGE

The Interference with Fertilization of the Nuts by Spray Applied During the Pollination Period.—Heavy losses may be occasioned by the interference of spray applied to the open flowers during the pollination period. Heavy losses may also be occasioned by imperfect pollination that has no connection with spraying. Some varieties are notorious for their failure to produce pollen at the time the flowers are open. Others fail only in certain years to release their pollen at the time the flowers are receptive. Growers should not blame losses of this kind on spray that has been applied at the correct time for the control of bacteriosis.

Spray Burn and Other Undesirable Effects.—The walnut is peculiarly sensitive to injury by spray materials that ordinarily have no bad effects on most other plants. Bordeaux 8–4–50 was found to be the least injurious of the many materials tried in the course of the experiments. In fact over a period of five years at widely separated points in the state and under the most diversified climatic conditions no spray burn was observed in any of the experiments. The possibility of bordeaux spray burn is acknowledged, however. From time to time growers cooperating with the writer reported burning of the foliage by the spray.

Ordinarily the burns occasioned by properly made bordeaux spray are of no great consequence. The damage is quickly outgrown and the crop in no way affected. Improperly made bordeaux may burn the walnut severely, or any other plant, for that matter.

The new tender foliage is susceptible to burn while it is still reddish in color. As it matures and turns green its resistance increases greatly. Fully developed foliage will tolerate repeated applications of bordeaux at full strength. Spray burn usually manifests itself by a withering and drying out of the leaflets (fig. 17). Frequently the margins alone are killed and distortions result when the living tissue grows away from the dead areas. Killed spots, circular or irregular in outline, may also develop on the blades. The killed tissue may fall out after it dries so that

the leaf becomes perforated and ragged in appearance. No actual defoliation in any appreciable amount occurs.

The factors that lead to spray burn of walnut foliage are imperfectly understood. Trees may be susceptible to the injury one year in a certain locality but not the next. This suggests the possible influence of climatic



Fig. 17.—Spray burn of English walnut foliage. The shoot on the right is normal. The shoot on the left shows the characteristic perforation and desiccation of the leaflets. (Two-thirds natural size.)

factors. Most burning seems to take place when the sprays are applied during hot windy weather when the humidity is low, but exceptions to this observation have been noted. It might be advisable to avoid spraying on warm days when the humidity is low, such as prevail at times in southern California.

Mr. Floyd Stone, in charge of one of the Bowman-Kuhn orchards at San Jose, has sprayed with bordeaux 8–4–50 for a number of years (see table 2, page 40, and table 3, page 42) with and without spray burn. His crop yields have been excellent. At the writer's request Mr. Stone tried different bordeaux formulas on large blocks of trees in an effort to find a mixture that would not burn the foliage under the conditions peculiar to the orchard. The results were unsatisfactory. When equal amounts of bluestone and lime were used, the spray burn was just as severe as when bordeaux 8–4–50 was used. Similarly, bordeaux used at half the usual strength, namely 4–2–50, occasioned as much burn as the mixture used at full strength. The method of mixing the spray seems to

have little bearing on the matter; the addition of either the lime or the bluestone to the tank first will not render the spray less likely to burn the foliage when climatic conditions are conducive to it.

Some growers have reported that bordeaux spray to which about 1 per cent of highly refined emulsified oil (100 per cent unsulfonated residue) has been added is less likely to burn the foliage than the straight mixture. Mr. Stone tried less highly refined oil emulsions at the same strength with the same object in view.[23] These oils were used because they are considerably cheaper. There seemed to be less burning where the combination was used, although it was not entirely prevented.

The Franquette, Mayette, and Eureka varieties seem more susceptible to spray burn than either the Payne or the Santa Barbara Soft Shell.

Mechanical Injuries Occasioned by the Spray.—Spray applied under pressure is likely to bruise and tear the foliage, particularly on the lower branches. Bruised and lacerated tissue may die and leave spots or perforations. Injured tissue may be damaged further by spray burn. Mechanical injuries of this kind are quickly outgrown and may be ignored. The proper manipulation of the spray gun when spraying the lower limbs will obviate much of this kind of damage.

THE PREPARATION OF BORDEAUX SPRAY

The ingredients which make up bordeaux spray are bluestone (copper sulfate), quicklime (calcium oxide), and water.

To designate the proportions of bluestone and quicklime used it is customary to write the formula immediately after the name of the spray, such as bordeaux 8–4–50. In such a formula the first figure always indicates the number of pounds of bluestone used, the second figure the number of pounds of quicklime, and the third figure the number of gallons of water.

The grower who intends to spray regularly, particularly if the orchard is a reasonably large one, should familiarize himself with the great advantages of an elevated platform from which concentrates or stock solutions can be run directly to the spray tank with less trouble, delay, and muss than when the spray must be mixed from barrels on the ground. An overhead water supply of good volume is practically indispensable. Also, for cleanliness and convenience, a level concrete base and

[23] The oil emulsions used were Orthol-K-Medium and Medium Summer Oil, manufactured by the California Spray Chemical Company, Berkeley, California, and the San Jose Spray Manufacturing Company, San Jose, California, respectively. Ordinarily neither emulsion is toxic in itself to walnut foliage.

drain for the spray rig to stand upon when the spray is being made, or when the tank is being washed out, is much to be recommended.

The following method is designed for the grower who has few or none of the conveniences described above, but in general the principles involved are the same as used in any method of making bordeaux.

Preliminary Preparations.—First, secure at least 4 water-tight, clean wooden barrels of 50-gallon capacity. To work with less than 4 barrels will delay the work of spraying, and since the nature of the disease is such that everything must be done to facilitate the job of spraying, it is poor economy to work with too few barrels. If the orchard is large and much spray is to be used, 6, 8, or even more barrels, will be found to be none too many once the work is under way. See that the barrels are thoroughly clean and well soaked up. Provide a coarse bristle brush and an extra barrel of water for the purpose of washing buckets, etc.

Place the barrels on level ground in a position convenient to the water supply. With a bucket or other liquid measure, the capacity of which is definitely known, very accurately pour 40 gallons of water into each barrel. Drive in two brass or copper nails opposite each other on the inside of each barrel at the 40-gallon level. Do not remove the nails, because the barrels will be used again and again. Empty the barrels.

Preparation of Stock Solution of Bluestone.—In each of two or more barrels, in which the 40-gallon level has previously been determined, dissolve 80 pounds of bluestone. The bluestone should be of good grade, which may be recognized by its deep blue or sapphire color. A green color indicates the presence of iron impurities, and such bluestone should be rejected. Place the bluestone in a clean, fairly loosely woven gunny sack free of holes. Avoid the use of heavy interwoven sacks which do not permit of free circulation of water within. Tie the sack closely to a wooden bar of some sort such as an old axe, pick, or broom-handle and suspend the bluestone in the middle of the empty barrel in such a way that it touches neither sides nor bottom. Pour boiling hot water into the barrel to dissolve the bluestone.

Boiling water is easily obtained as follows when no more convenient source is at hand: Dig a fairly deep trench close to the water supply and away from the wind. Place four iron bars or pieces of pipe across it to support two ordinary 10-gallon wash tubs full of clean water. The tubs should be provided with flat tin lids. Build a good fire in the trench, which for the sake of convenience should be dug not wider than the tubs. The contents of the two tubs (roughly 20 gallons) will quickly come to a boil and will be sufficient to dissolve the bluestone in one barrel in a few minutes. Cold water may be added either before or after all of the bluestone has dissolved to bring the water level up to the 40-gallon mark. If

luke-warm water is used it may take several hours to dissolve the bluestone. If cold water is used it may take several days, according to the chill of the water. To speed up the solution of the bluestone, the sack may be shaken from time to time.

When the last bluestone crystals have disappeared remove the sack from the barrel. Carefully note whether the solution has reached the 40-gallon mark. If not, add the necessary amount of cold water to bring up the level. Stir the solution with a wooden paddle until it is evenly mixed throughout. Once thoroughly mixed it needs no further stirring at any time, and the paddle may be removed. The barrel now contains 40 gallons of bluestone stock solution (not 40 gallons of water) in which 80 pounds of bluestone have been dissolved. Each gallon of solution, therefore, contains 2 pounds of bluestone. The stock solution is ready for use.

Under no circumstances prepare bluestone stock solution in an iron barrel or other vessel in which iron is exposed because the bluestone will destroy it. Even iron nails used to mark levels in barrels will disappear, necessitating recalibration of the 40-gallon level.

Preparation of Stock Solution of Lime.—Since only one-half as much quicklime is used as bluestone in the bordeaux 8–4–50 formula, smaller quantities of lime stock solution may be made.

In one or more clean, empty wooden or iron barrels, the 40-gallon level of which has previously been determined, dump 80 pounds of good-quality, freshly burned quicklime (unslaked lime). Add cold water until the quicklime is almost covered, and allow the mixture to come to a boil of its own accord. Sluggish lime which will not raise the temperature of the water to the boiling point should be returned to the dealer who supplied it. Quicklime rapidly deteriorates on exposure to the air and becomes "air-slaked." As the quicklime air-slakes it sloughs away from the lump form in which it usually comes, into a very fine, flour-like, white dust. The presence of much of this white dust in the barrel should cause it to be looked upon with suspicion. Air-slaked lime is utterly worthless in the preparation of bordeaux, and serious burns may result if it is used. Many companies manufacturing quicklime realize the difficulty of keeping it fresh in wooden barrels and now pack their product in air-tight tin drums. Such quicklime if originally obtained from a good quarry is apt to be the best. Some companies using metal drums pulverize the quicklime to conserve space. Such pulverized or powdered quicklime is as good as any provided it is fresh. In such cases the readiness and thoroughness with which it reacts with water will be the sole proof of its freshness.

Some pulverized quicklimes of high purity, packed in metal drums, are so violent in their reaction with water that it is often desirable to start with the barrel about two-thirds full of cold water instead of empty as described above. The requisite amount of quicklime should be poured into the water at a rapid rate. Ordinarily the entire amount can be introduced into the barrel before the temperature of the water is raised to the boiling point. If the mixture becomes violent before all the quicklime has been introduced, the worker should wait a moment until the reaction subsides. Or the temperature can be lowered by the addition of more cold water to the barrel, after which the remainder of the quicklime may be added conveniently.

The quicklime should be stirred occasionally while it is being slaked to insure that water reaches all of it. Add water from time to time to prevent the mass from drying out and finally enough to bring the level up to the 40-gallon mark. After the reaction is complete and boiling has ceased, the mixture should be stirred vigorously for a few minutes until all lumpy material or paste in the bottom of the barrel has disappeared and a smooth "milk of lime" obtained. Small quantities of impurities such as grit, rock, or unburned lime may be ignored.

The barrel now contains 40 gallons of lime stock solution (not 40 gallons of water) in which 80 pounds of quicklime have been slaked. Each gallon therefore contains 2 pounds of quicklime. The lime stock solution is ready for use.

Preparation of the Spray from the Stock Solutions.—The stock solutions of bluestone and lime should be made at a convenient time before they are apt to be needed. Each one separately keeps practically indefinitely but when one is added to the other the resultant mixture must be used at once, as it deteriorates rapidly on standing, losing both its adhesive properties and its value as a disinfectant.

The spray should always be prepared with cold water. There is no objection to using the stock solutions while they are still hot, however, if the following method of mixing the spray is observed.

First determine the amount of bluestone and lime stock solution that must be used to make a tank of bordeaux 8–4–50. The formula itself provides for 50 gallons of spray only. Multiply the numbers of the formula by the number of times that 50 gallons will go into the spray tank. The calculations for 200, 300, and 400-gallon tanks would be as follows:

8–4–50	8–4–50	8–4–50
× 4	× 6	× 8
32–16–200	48–24–300	64–32–400

Thus for a 200-gallon tank, it will be necessary to use 32 pounds of bluestone and 16 pounds of quicklime as shown above. Since each gallon

of the stock solutions contains 2 pounds of either bluestone or quicklime, it will be necessary to take 16 gallons of bluestone stock solution and 8 gallons of the lime stock solution to give the requisite amounts.

The amount of stock solution to use in tanks of other sizes is determined in exactly the same way; thus for a 400-gallon tank, take 32 gallons of the bluestone stock solution and 16 gallons of the lime stock solution to give the requisite amounts of bluestone and quicklime.

Dip the bluestone solution with a wooden bucket; it destroys iron pails quickly. Always wash the pails after finishing with one solution before using them in the other.

To mix the spray proceed as follows: First fill the tank ½ to ⅔ full of clean, cold water. Next add the bluestone stock solution through a sieve of about 20 meshes to the inch, to exclude grit and other foreign substances which otherwise may reach the valves or nozzles and give trouble. Start the agitator running, and add the requisite amount of lime stock solution last. Always stir the lime stock solution vigorously before drawing, because the lime tends to settle out on standing. If the solution is thoroughly stirred each time before using it will be no more concentrated at the bottom of the barrel than at the top. When the lime stock solution is thoroughly mixed it should run freely through the sieve into the tank. Lime stock solution that is pasty may be hosed through the sieve easily. Carefully remove the sieve and shake out the grit, dirt, and other débris.

Fill any space that may remain in the tank with water and proceed to spray at once. Never stop the agitator at any time after starting to mix the spray until the last of it has been applied to the trees.

Opinions are divided as to whether the bluestone or the quicklime should be added to the tank first. There seems to be little difference in the bordeaux produced by the two methods or in the effects produced on the walnut tree. The writer has always added the bluestone to the tank first and the lime last with excellent results.

Stock solutions left over may be saved for use later on. Drive a copper nail at the level of the solution when finished with it. Just before using the solution add water to bring the level up to the nail, to replace the water that has been lost by evaporation. Stir the mixture vigorously, and the original 2-pounds-to-a-gallon ratio will be restored.

The Use of Commercial Bordeaux.—The use of bordeaux powders in which the bluestone and quicklime have been combined chemically is not advised. The adhesive properties of such powders are very poor and their value as disinfectants distinctly inferior to those of freshly prepared bordeaux.

So-called "two package," "twin," or "instant" bordeaux more closely approximates the freshly prepared spray than does the powdered form. In such preparations the bluestone is contained in one bag, lime in another. The bluestone is powdered fine enough to dissolve readily in cold water when added to the tank, thus obviating the use of hot water as described earlier in this section. The lime is already slaked (hydrated) and need not be prepared in advance as when quicklime is used. Some bordeaux chemists not averse to commercial bordeaux of this type recommend soaking the hydrated lime overnight in water, however, before making the spray, for best results. This, of course, necessitates the use of barrels as when bordeaux is made from quicklime.

The greatest recommendation of commercial preparations of this type is the ease with which bordeaux spray can be prepared from them. They possess certain objectionable features, however, which may lead to serious trouble at times. Dry hydrated lime when exposed to air is readily converted into a carbonate and as such is utterly useless in the preparation of bordeaux. The paper bags in which the hydrated lime is sold are not wholly impervious to air. Likewise they are easily punctured; this permits air-slaking to take place, though the change is not evident in the appearance of the material. The more reputable manufacturers recognize this danger and replace it in the market with fresh material after a reasonable length of time. Severe burns may result when old lime is used.

There can be no objection to the use of pulverized bluestone in the preparation of bordeaux spray provided the price is satisfactory and the material ground fine enough to permit of complete and immediate solution in cold water when it is added to the tank. The writer has used some commercial products, however, which did not dissolve readily but collected in the corners and bottom of the spray tank. This may happen even with the best material if sufficient agitator blades are not used or if some of them are not properly adjusted. Undissolved bluestone sprayed on the foliage will cause burns. Freshly prepared bordeaux spray was used exclusively in all the experiments reported in this paper, but certain excellent results have been obtained by walnut growers with the two-package type. From the standpoint of cheapness and efficacy, homemade bordeaux, the preparation of which is described on page 71, cannot be excelled.

LIST OF MATERIALS TRIED WITH DOUBTFUL, LIMITED, OR UNFAVORABLE RESULTS

For the sake of record a report is given here of the various spray materials tried with limited, doubtful, or unfavorable results. Some of the materials seemingly produced good results on their first trial but failed to repeat them in subsequent experiments. Others burned the foliage or poisoned the trees. As a whole they may be regarded as failures. Individual materials need be discussed in detail sufficient only to show why they were unsuited.[24]

Highly Refined Oil Emulsions (Unsulfonated Residue 100 per cent).—Several types were used at 2 and 5 per cent strengths in single and multiple applications as described on page 33. They afforded no protection whatever.

Basic Copper Acetate.—This material was used at the rate of 4 pounds in 50 gallons of water, either with or without ground glue (previously dissolved in hot water) at the rate of 1 pound to 50 gallons of spray as an adhesive. Single and multiple applications were given as described on page 33 for a period of three years. Basic copper acetate afforded an appreciable amount of control at times, but bordeaux 8–4–50 used alongside of it under identical conditions consistently gave better results. At times there was a distinct tendency on the part of the copper acetate spray to russet the foliage and nuts. This was avoided by reducing the strength from 4 pounds to 3 pounds in 50 gallons of water.

Ammoniacal Copper Carbonate.—The standard formula was used:

Copper carbonate	5 ounces
Ammonia (26° Baumé)	3 pints
Water	50 gallons

Used in moving plots over a period of several years, this spray, like basic copper acetate, afforded an appreciable amount of control, but was inferior to bordeaux 8–4–50. Unlike basic copper acetate it did not burn or russet the foliage.

Borco, a proprietary product said to produce ammoniacal copper carbonate when dissolved, was used at the rate of 12 pounds in 200 gallons of water. Borco Spred at the rate of 1 pound in 200 gallons of the spray was added according to the directions of the manufacturers.[25] Used in

[24] Many of the chemical and proprietary spray materials reported here as failures in the control of walnut bacteriosis have been found highly effective in the control of other plant diseases. It was their success in other fields that led to their use in the present experiments. The fact that they failed to control bacteriosis should not prejudice growers against their use in fighting diseases for which they may be better suited.

[25] "Borco" and "Borco Spred" are manufactured by the Rex Research Company Inc., of Toledo, Ohio.

moving plots as described on page 33 the results were identical with those obtained with freshly prepared ammoniacal copper carbonate.

Acid Bordeaux.—A solution of bluestone (8 pounds to 50 gallons of water) was treated with such small amounts of quicklime (previously slaked in water) that the resultant bordeaux was definitely acid to litmus. After 10 minutes' agitation some of the spray was filtered and the filtrate tested with a solution of potassium ferrocyanide for the presence of soluble copper. A bright rose or pink color was produced, showing copper to be present in the filtrate.

Acid bordeaux was applied in moving plots as described on page 33. Its action was undependable; rather severe burns were occasioned one year and not the next. The worst damage occurred on the trees to which the spray had been applied several times.

While acid bordeaux showed distinct disinfectant properties (see table 2, page 40), the control afforded by it was no greater than that of the alkaline mixture. Its greater tendency to burn the foliage and the difficulty of preparing it make its use inadvisable.

Neutral Bordeaux.—Prepared exactly like acid bordeaux but with the addition of more quicklime to make the spray neutral to red or blue litmus. The filtrate when tested with potassium ferrocyanide failed to show the presence of copper ions.

The results obtained with neutral bordeaux were practically indistinguishable from those of acid bordeaux. Undependable in its action on the foliage, it sometimes occasioned pronounced burns, at other times no appreciable damage. Its use by growers is not considered advisable.

Excessively Alkaline Bordeaux.—Various bordeaux formulas were tried in which the quicklime content varied in weight from an amount equal to that of the bluestone used to twice as much. None of these sprays afforded any greater control than bordeaux 8–4–50. Sprays of this type are harder to apply and leave a very dense, opaque residue resembling whitewash, which is highly undesirable on the shoots and foliage. When bordeaux 6–12–50 was used, the very great excess of lime present was injurious to the valves and pressure regulator of the spray pump. The seating pin in the latter had to be replaced from time to time as the result of the abrasive action of the spray.

Semesan.—Semesan (hydroxymercurichlorophenol sulfate 30 per cent, inert material 70 per cent) formerly was manufactured by E. I. Du Pont de Nemours and Company of Wilmington, Delaware, and was used in moving plots on Payne walnut trees at the rate of 0.25 per cent for the first two applications. In blocks of trees receiving the third and fourth applications in summer, the strength was cut to 0.12 per cent, because it was observed that with the approach of warm weather the

foliage sprayed with the stronger concentration turned yellowish and at times showed a faintly speckled condition reminiscent of, but not always identical with, true spray burn. Even at weaker concentrations the material applied in midsummer induced this same condition in trees sprayed for the first time. In another moving plot, the experiment was duplicated in every detail except that Volck oil, 2.0 per cent in strength, was used in combination with the Semesan.

In all blocks of trees sprayed with Semesan alone or in combination with oil, there was no appreciable control of the disease regardless of the number of applications given.

The trees appeared to be normal at the close of the season, but during the following winter they died back badly, in many instances almost to the main trunk, regardless of the strength at which the material had been used or whether it had been combined with oil or used in single or multiple applications. The severest damage was observed in the blocks receiving multiple applications of the spray. Symptoms of poisoning were very apparent the following spring; the new foliage appeared much later than that on adjoining unsprayed trees and was yellowish in color. Growth was sluggish throughout the season. *Melilotus* seed planted for a covercrop during the winter failed to germinate under the trees sprayed with Semesan. Outside of the sprayed plots, however, there was a luxuriant growth waist high.

Uspulin.—Uspulin (hydroxymercurichlorophenol sulfate 30 per cent, inert material 70 per cent) formerly manufactured by the Bayer Company of Rensselaer, New York, has been withdrawn from the market. It was used at the rate of 0.25 per cent with and without 2.0 per cent Volck oil in moving plots on Payne walnut trees, from one to four times. As in the case of Semesan the strength of the Uspulin had to be reduced to 0.12 per cent with the approach of warm weather. Uspulin alone or in combination with oil produced highly undesirable effects, identical with those produced by Semesan, regardless of its strength or whether it was used in single or multiple applications. A comparison of the weights of nuts from sprayed and unsprayed plots adjoining revealed no appreciable control of the disease. The quality of the nuts from sprayed trees was distinctly inferior to those from unsprayed trees. During the winter following the experiment the sprayed trees died back badly. *Melilotus* seed planted for a covercrop failed to germinate under the sprayed trees.

Dip Dust.—Dip Dust (hydroxymercurichlorophenol sulfate 6 per cent, hydroxymercurinitrophenol sulfate 2 per cent, inert ingredients 92 per cent) formerly manufactured by the Bayer Company of Rensselaer, New York, has been withdrawn from the market. Used at 0.25 per cent

strength it gave considerable promise, but final conclusions could not be drawn under the conditions of the experiments. Large blocks of trees sprayed one and two times with it early in the growing season of 1928 were seemingly unaffected in any way. The crop was lost to frost, however, and the value of Dip Dust as a disinfectant could not be determined. The following year with limited material available, 11 trees were sprayed a single time with it when the nuts were about the size of peas. No ill effects were noted throughout the balance of the season. In a part of the orchard where the natural set of fruit varied considerably, the trees sprayed with Dip Dust produced a huge crop, averaging 216 pounds hulled nuts per tree, wet weight, against 171 pounds average on 11 check trees seven rows away. Dip Dust was very expensive, and it is doubtful whether it would pay to use it regularly. Dip Dust was almost entirely colloidal and practically insoluble in water in contradistinction to Semesan and Uspulin, which were almost entirely soluble.

Neko.—Neko is a germicidal soap containing 2.0 per cent mercuric iodide manufactured by Parke, Davis, and Company of Detroit, Michigan. It was used at strengths varying from 0.25 per cent to 0.10 per cent on Payne walnuts. Even at the weaker concentration it caused severe burning of the leaves, retarded the growth of the new shoots, and stunted the nuts in size. Pending further experiments its value as a disinfectant must remain undecided.

Iodine.—A saturated alcoholic solution of iodine was prepared by placing an excess of iodine crystals in methyl alcohol. The solution was used at 0.50 per cent strength in water in which 2.0 per cent fresh quicklime previously had been slaked. Also it was applied as weak as 0.06 per cent in water containing 1.0 per cent cooked cornstarch, added as an adhesive. At any strength at which it was used the iodine caused severe burning of the foliage of Payne walnuts, delayed the new growth, and stunted the nuts in size. No trees were sprayed more than once with iodine in any dilution because of the severe reactions which it caused. After two years' trial this element was considered unsuited for use as a disinfectant on walnuts.

Liquor Cresolis Compound, Surgical.—A liquid soap containing 50 per cent Cresol, U. S. P., manufactured by the Michel and Pelton Company of Oakland, California, used at 0.5 per cent strength in water, in which 1.0 per cent fresh quicklime had previously been slaked. Payne walnut trees were sprayed with the mixture when the new growth was starting in the spring and again when the nuts were the size of peas. No ill effects were noted. The crop was destroyed by frost, consequently the value of the spray could not be determined. Used the following year only once at 0.35 per cent strength without any lime on 11 trees when

the nuts were the size of peas, the mixture occasioned no injury. The disease developed as early on the sprayed trees as on check trees close by, and a comparison of the weight of nuts from the two plots at harvest showed no evidence of control. The possibilities of this material were not exhausted, but in view of the volatile nature of its active principle it is not likely that bacteriosis can be effectively controlled with it.

Sodium Fluosilicate.—Sodium fluosilicate was applied at the rate of 8 ounces in 400 gallons of water to Payne walnut trees from one to four times in moving plots. In a similar moving plot the material was applied from one to four times at the same strength in combination with 2 per cent Volck oil. The cumulative effect of the sodium fluosilicate was very bad, either when used alone or in combination with oil. Even at the very weak concentration at which it was used it burned the foliage severely. No control of the disease was effected, there being just as many good nuts harvested in the check plots on all sides as in any of the sprayed blocks.

Calcium Chloride.—Calcium chloride was used at the rate of 1.0 per cent concentration in water from one to four times on Payne walnut trees in moving plots. In a similar moving plot this material was used again at the same strength in combination with 2.0 per cent Volck oil. Used alone or in combination with oil the calcium chloride produced undesirable effects on the trees. Less apparent in plots sprayed once, spray burn was very noticeable in plots sprayed several times. The material effected no appreciable control of the disease; the crop was just as large by weight in check plots on all sides as in the plots sprayed with calcium chloride alone or in combination with oil.

Potassium Permanganate.—Potassium permanganate was used at 1.0 per cent concentration in water in limited experiments from which no final conclusions as to its worth as a disinfectant could be drawn. The material occasioned no damage to the trees. Because of the rapidity with which potassium permanganate loses its disinfectant properties it is not likely to prove satisfactory as a spray in the control of walnut bacteriosis.

Zinc Sulfate and Quicklime.—The method of preparing the spray is similar to that of bordeaux. The formula used was 4–4–50. The zinc sulfate was added to a spray tank about two-thirds full of water. The agitator was started and the lime (previously slaked separately) poured in. The tank was then completely filled with water.

This mixture was tried only once on Payne walnuts during the prebloom stage. There were no appreciable results. The experiment was never repeated and no final conclusions were drawn.

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FOREIGN PRODUCTION, TRADE, AND GOVERNMENT AID IN THE RAISIN AND CURRANT INDUSTRY

WALTER BAUER

Results of a coöperative investigation conducted by Division of Foreign Agricultural Service, Bureau of Agricultural Economics of the United States Department of Agriculture and the California Agricultural Experiment Station

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FOREIGN PRODUCTION, TRADE, AND GOVERNMENT AID IN THE RAISIN AND CURRANT INDUSTRY[1, 2]

WALTER BAUER[3]

INTRODUCTION

The rapid growth of California raisin exports since the World War has greatly increased the dependence of the industry upon foreign markets and has brought a substantial part of the California sales into direct competition with raisin and currant supplies from other producing countries of the world.[4] Exports during the five years before the War averaged only about 13 per cent of the California raisin crop. After the War they increased rapidly until, with very large supplies and extremely low prices, they reached a peak in 1928 of 119,000 tons (sweatbox basis), or approximately 41 per cent of California raisin shipments for the crop year. It appears that California may now normally expect to be dependent on foreign markets to absorb approximately 30 per cent of the state raisin output.

The importance of keeping abreast of current and prospective developments in the economic situation of the raisin industry of foreign countries has, therefore, been greatly accentuated since the World War by the direct and keen competition that California's greatly increased raisin exports have been forced to meet in foreign markets from raisin and currant supplies from other producing countries. The failure of the

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[2] Paper No. 50, The Giannini Foundation of Agricultural Economics.

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[4] Foreign competition in the American market has been checked effectively by the tariff and by the inability of foreign sources of supply to compete with the highly organized industry in California. In 1920, for instance, imports of raisins and other dried grapes into the United States amounted to 46,039,000 pounds and imports of currants to 55,832,000 pounds. The corresponding figures for 1930 were 1,834,000 pounds of raisins and other dried grapes, and 8,716,000 pounds of currants. The rate of decrease during these ten years was much greater in the case of raisins and other dried grapes than in the case of currants.

raisin and currant industries of the world to market all of their output in recent years, even at prices ruinously low to many growers, indicates that overproduction exists and has led to a particularly keen competitive struggle between producing countries. For many years currant production has continuously been greater than the amount world markets have taken for eating purposes, and during the last ten years raisin production has frequently been in excess of what consumers have bought even at very low prices.

Excessive raisin supplies are exceptionally depressing upon prices because of the very inelastic demand. Such drastic price cuts have to be made to induce any substantial increase in raisin consumption in the United States that excessively large crops return smaller incomes to growers than small crops.[5] Naturally, a situation of overproduction of a crop with such an inelastic demand has led to organized attempts in several producing countries to remove entirely surpluses from world markets and to control prices artificially. The most noteworthy experiments along this line are those of the Central Currant Office of Greece, the Australian Dried Fruit Control Board, and the California Grape Control Board and the Raisin Pool.[6] Other methods have also been used by governments and by growers and packers in a number of countries in attempting to remedy the economic difficulties of their raisin and currant industries.

OBJECT OF STUDY

The increasing importance of government aid to the raisin and currant industries of foreign countries has made it desirable to study the nature, method, and results of such government measures in order properly to appraise the influence that they have had and that they are likely to have upon world raisin production and trade. In this study, however, it has been found practically impossible to secure all of the facts necessary to arrive at precise conclusions regarding the true economic effects of government assistance on the raisin and currant industries of the countries concerned, and, through the medium of the world raisin market, on the California raisin industry itself.

In the first place, the available data on the subject proved to be insufficient to permit of conclusions without many reservations. Inadequate data leave many vital questions only partially answered regard-

[5] Shear, S. W. and R. M. Howe. Factors affecting California raisin sales and prices, 1922–1929. Hilgardia 6:78–79. 1931.

[6] For a discussion of the California raisin control plan and its operation through May, 1931, see: Shear, S. W. The California grape control plan. Amer. Coöperation, 1931. 1:229–247. 1931.

ing present and future acreage, production, markets, and demand. Of necessity, the data used in the study have been very largely drawn from published literature supplemented, in some instances, by facts secured by conference or by correspondence with persons familiar with the raisin and currant industries of some of the countries involved. Additional and somewhat more satisfactory information presumably could have been secured by travel and observation in the countries involved and by conference with the persons in those countries best informed regarding the raisin and currant industries, but such a personal survey was out of the question.

Secondly, the complications in the international raisin market are of such recent date that many of the government relief measures of recent years have not yet exercised their potential influence, especially since they are still largely experimental.

In the third place, the development of the world's raisin and currant industry is intimately associated with the economic outlook and prosperity of the world in general. Raisins and currants are largely a luxury foodstuff. Their consumption is affected by such factors as purchasing power, patriotic loyalty in economic matters, economic reciprocity between purchasing and selling countries, and the fact that some thickly populated and potential consuming regions have not yet been exploited as markets.

Finally, the human factor gains special importance when one takes into consideration the possible psychological effects of skillful advertising and aggressive salesmanship, by which consuming habits and preferences may be vitally changed. This brings into the picture the possible competition of fresh and canned fruit which may become more serious, if this type of consumption is strongly pushed forward.

In general, the factors that determine the demand for raisins and currants in foreign markets are so varied and complicated that they can only be referred to superficially in a study such as this, which is to be confined mainly to an investigation into the development of the raisin and currant industry through government encouragement and support. The data available do not permit precise conclusions concerning the probable effects of government interference abroad on the California raisin industry nor what should be done by the California grower to safeguard his interests in view of the potential competitive strength of foreign producing regions. However, the facts presented on foreign developments should give the California raisin industry a clearer picture than has previously been available of what it may have to contend with in export markets from foreign raisins in the future. Such a study of

the measures that foreign governments have used to help foster their own raisin and currant industries may also suggest whether similar experiments with the California raisin industry would appear to be feasible or not.

TABLE 1

WORLD RAISIN AND CURRANT PRODUCTION BY COUNTRIES, AVERAGES 1909–1913, 1921–1925, AND 1926–1930

Country	1909–1913	1921–1925	1926–1930	Per cent of total		
				1909–1913	1921–1925	1926–1930
	short tons	*short tons*	*short tons*	*per cent*	*per cent*	*per cent*
Currants:						
Greece	174,570	142,936	147,646	97.7	92.4	90 3
Australia	4,045*	11,714	15,659	2.3	7.6	9.6
Union of South Africa	6†	79	164	‡	‡	0.1
Total currants	178,621	154,729	163,469	100.0	100 0	100 0
Raisins:						
California (United States)	71,700	208,400	244,940	28.4	55.9	54.9
Australia	6,753*	21,671	44,910	2.7	5.8	10.1
Smyrna (Turkey)	52,580	41,280	47,980	20.8	11.1	10.7
Spain (exports§)	26,170‖	21,523	21,365	10 4	5.8	4.8
Persia (exports¶)	32,960**	19,961	19,563	13.0	5.3	4.4
Greece (including Crete)	18,000††	21,000	21,660	7.1	5 6	4.8
Cyprus (exports)	3,416	3,011	5,058	1.3	0.8	1.1
Union of South Africa	1,257†	5,622	4,918	0.5	1.5	1.1
Subtotal	212,836	342,468	410,394	84.2	91.8	91 9
Russia	30,000††	20,000††	25,000††	11.9	5.3	5.6
Italy	8,000††	7,000††	6,000††	3.2	1.9	1.3
Argentina	300††	1,500	3,000	0.1	0.4	0.7
Chile	729	1,000††	1,000	0.3	0.3	0.2
Palestine and Transjordania	750††	1,000††	1,120††	0.3	0.3	0.3
Total raisins	252,615	372,968	446,514	100.0	100 0	100 0
Total raisins and currants	431,236	527,697	609,983			

* Victoria and South Australia only.

† 1911 only.

‡ Less than one-tenth of one per cent.

§ Exports from the Valencia-Alicante and Málaga districts. Data for 1920-1930 include shipments by sea to Spanish markets, but it is not known whether or not such shipments are included in the 1909-1913 average.

‖ Average, 1909-1912.

¶ For years beginning March 22 (for all other figures in this table calendar years are used).

** Average, 1911-1913.

†† Estimated.

Sources of data:

Currants: 1909-1913: for Greece from table 5; Australia from table 41; Union of South Africa from table 48.

1921-1930: from table 2.

Raisins: 1909-1913: for California from Shear, S. W., and H. F. Gould. Economic status of the grape industry. California Agr. Exp. Sta. Bul. **429**: 124. 1927; Australia from table 41; Smyrna from table 18; Spain from table 28; Persia from table 35; Greece from table 16; Cyprus from table 23; Union of South Africa from table 48.

All data 1921-1930: from table 2, except as indicated below.

All data for Russia, Italy, Argentina, Chile, Palestine, and Transjordania are estimates based upon best data available from official sources and trade information.

TABLE 2

World Raisin and Currant Production by Chief Countries, Years Harvested, 1920–1932¶

Country	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932*
	short tons	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*
Currants:													
Greece	145,475	129,605	128,547	105,800	178,802	171,925	148,914	142,618	155,900	143,400	147,400	73,700	144,000
Australia	8,042	7,647	9,080	11,755	17,040	13,050	13,704	14,289	7,950	21,160	21,192	19,411	19,094
Union of South Africa	34	39	60	90	107	100	91	109	96	216	308	225	225
Total currants	153,551	137,291	137,687	117,645	195,949	185,075	162,709	157,016	163,946	164,776	168,900	93,336	163,319
Raisins:													
California (United States)	177,000	145,000	237,000	290,000	170,000	200,000	272,000	285,000	261,000	215,000	191,700	169,000	262,000
Australia	15,726	9,418	15,121	20,876	33,063	29,876	27,751	48,722	28,791	59,388	59,898	36,761	45,765
Smyrna (Turkey)	20,300	37,400	41,200	40,400	54,300	33,100	39,100	52,900	50,200	56,200	41,500	31,000	70,000
Spain (exports†)	33,000‡	19,313	20,510	17,950	23,613	26,229	20,650	25,227	22,673	20,701	17,574	15,945	20,300
Persia (exports‖)	—§	5,965	11,088	21,304	30,774	30,672	14,458	26,226	21,876	17,881	17,374	29,139	20,000
Greece (including Crete)	13,000	22,000	21,000	18,000	22,500	21,500	20,000	22,300	22,500	22,000	21,500	21,500	27,000
Cyprus (exports)	2,033	1,983	2,020	2,113	5,137	3,803	3,700	4,925	5,453	5,437	5,776	2,989	3,492
Union of South Africa	2,586	4,197	7,820	5,910	5,523	4,660	4,564	5,146	5,414	4,964	4,502	4,650	4,650
Total raisins	—	245,276	355,759	416,553	344,910	349,840	402,223	470,446	417,907	401,571	359,824	310,984	453,207
Total raisins and currants	—	382,567	493,446	534,198	540,859	534,915	564,932	627,462	581,853	566,347	528,724	404,320	616,526

* Preliminary data, subject to revision.

† Exports from the Valencia-Alicante and Málaga districts for approximate crop years. Include shipments by sea to Spanish markets.

‡ Estimated.

§ Dashes indicate data not available.

‖ For years beginning March 22. (For all other figures calendar years are used.)

¶ Preliminary 1933 production estimates for most of the countries included in this table are given in tables in sections dealing with individual countries.

Sources of data:

Currants: Data for Greece from table 5; Australia from table 41, except for 1928-1932 which are from the Australian Dried Fruits Association; Union of South Africa from table 48.

Raisins: Data for California (which exclude dried grapes) compiled from California Crop Reports; Australia from table 41, except for 1928-1932, which are from Australian Dried Fruits Association; Smyrna from table 18; Spain from tables 33 and 34, except for 1920, and exports to Spanish markets for 1921 which are estimated from best data available; Greece from table 16; Persia from table 35; Cyprus from tables 23 and 24; Union of South Africa from table 48.

TREND OF WORLD PRODUCTION AND CONSUMPTION

Production.—During the last twenty years world production of raisins has increased greatly while currant production has declined slightly.

TABLE 3

NET RAISIN IMPORTS INTO PRINCIPAL IMPORTING COUNTRIES, CALENDAR YEAR AVERAGES, 1909–1913, 1921–1925, AND 1926–1930

Importing countries	1909–1913	1921–1925	1926–1930
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
United Kingdom	78,510*	109,443*	154,729
Germany	39,900	27,009	69,909
Canada	22,331	34,537	40,662
France§	17,294	9,071	12,634
Netherlands	10,598	13,292	23,123
Belgium	5,132	7,080	11,033
New Zealand	4,678	6,732	9,016
Irish Free State	—*†	4,648‡	6,011
Denmark	3,635	3,717	5,447
Sweden	3,624	3,075	4,636
Norway	3,091	3,361	4,221
Finland§	2,879	3,328	4,772
Italy	2,404	1,937	5,199
British India§‖	2,269¶	2,152	1,994
Switzerland§	2,078	1,751	2,641
Philippine Islands	441**	466	692
Subtotal	198,954	231,599	356,719
Poland	—†	5,748‡	2,100
Egypt	—	4,087	3,805
Austria	—	3,931††	7,889
China§	—	3,826‡‡	5,171
Czechoslovakia	—	3,732	6,434
Jugoslavia	—	163	2,037
Hungary§	—	272‡	920
Total	—	253,358	385,075

* The Irish Free State is included with the United Kingdom previous to April 1, 1923.
† Dashes indicate data not available.
‡ Two-year average, 1924-1925.
§ Includes currants.
‖ Year beginning April 1. Sea-borne trade only.
¶ Two-year average, 1912–13 and 1913–14.
** Year beginning July 1. Two-year average 1909–10 and 1910–11.
†† Four-year average.
‡‡ Three-year average, 1923-1925.

Sources of data:
Compiled from official sources by the Foreign Agricultural Service of the United States Department of Agriculture. Data for 1930 in some instances may be preliminary and therefore the 1926–1930 average may be subject to minor changes.

Tables 1 and 2 show that the big decline in currant production has taken place in Greece, while the rapid expansion of the raisin output has occurred in Australia and California. The combined total of world production of raisins and currants has grown from a pre-war average

(1909–1913) of roughly 430,000 tons[7] to over 600,000 tons in recent years. This increase of approximately 170,000 tons, or about 40 per cent, has been due entirely to the great expansion of raisin production which grew from an average of about 250,000 tons to an average of over 445,000 tons in the years 1926–1930. On the other hand, currant production de-

TABLE 4

NET CURRANT IMPORTS INTO PRINCIPAL IMPORTING COUNTRIES, CALENDAR YEAR AVERAGES, 1909–1913, 1921–1925, AND 1926–1930

Importing countries	1909–1913	1921–1925	1926–1930
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
United Kingdom	137,625*	129,997*	126,716
Germany	36,342	12,678	21,849
Netherlands	26,304	24,798	23,075
United States	31,916†	25,704	10,869
Canada	11,590	5,762	5,208
Irish Free State	—*‡	7,789§	7,420
New Zealand	2,621	1,385	1,311
Union of South Africa	1,851‖	864	967
Denmark	742	660	570
Poland	—‡	258	1,211
Norway	305	364	277
Sweden	232	277	340
Czechoslovakia	—	88	167
Egypt	—	55	58
Total	249,528¶	210,679	200,038

* The Irish Free State is included with the United Kingdom previous to April 1, 1923.
† Year beginning July 1.
‡ Dashes indicate data not available.
§ Two-year average, 1924–1925.
‖ Includes raisins.
¶ Excludes imports from Poland, Czechoslovakia, and Egypt, for which no data are available.

Sources of data:
Compiled from official sources by the Foreign Agricultural Service of the U. S. Department of Agriculture. Data for 1930 in some instances may be preliminary and therefore the 1926–1930 averages may be subject to minor changes.

clined from a little less than 180,000 tons to slightly over 160,000 tons during the same period.

Expansion of the California raisin output from a pre-war average of about 70,000 tons to a recent average of about 245,000 tons has accounted for much of the increase in world raisin supplies. Outside of California the greatest growth has taken place in Australia, largely as a result of post-war government measures developing and colonizing irrigated areas well adapted to raisin industry. From less than 7,000 tons, in pre-war years, the Australian raisin output has risen to an average of 45,000 tons in recent years. Somewhat offsetting the influence of the phenomenal growth of California and Australian raisin production

[7] All tonnage data in this bulletin are given in short tons unless otherwise stated.

since 1910 has been the slight decline in the raisin output of Smyrna and Persia. Smyrna production has declined from about 53,000 tons in pre-war years to an average of about 48,000 tons at present (1926–1930) while Persian output is now estimated to average approximately 30,000 tons (see page 86), or about 12,000 tons below the pre-war average (see table 35).

Consumption.—The decrease in world currant production is largely the result of the increasing preference of consumers for the seedless raisin of the sultana type which, for most purposes, can be used instead of currants. The very low raisin prices prevailing in recent years, as a result of excessive supplies, together with extensive trade-promotion activities, have been the chief causes of the big post-war increase in world consumption of raisins. However, neither the absolute nor the relative reduction in currant consumption during the past decade has been as great as the increase in raisin consumption. The rapid extension of the market for raisins (see table 3) has undoubtedly checked the growth of the currant industry in Greece, and has actually decreased currant consumption in several important markets (see table 4). However, it appears that no rapid displacement of currants by raisins is likely to occur during the next decade on the most important currant market—the United Kingdom. In several Continental European countries, such as Germany and the Netherlands, consumption appears to depend primarily on price rather than quality or other factors, the bulk of the demand being for whichever product—raisins or currants—is cheaper.

THE GREEK CURRANT INDUSTRY[8]

Next to California, Greece is the world's largest producer of raisins and currants combined and accounts for about a third of the world total (see table 1). Currants constitute by far the bulk of the Greek production of dried vine fruits. Until recent years, Greece held a natural mo-

[8] General sources used for this section in addition to those given in specific footnotes:

Avarna, Giuseppe. La produzione ed il commercio della passoline in Grecia Italy. Ministero di Agricoltura. Bollettino di Notizie Agrarie. October, 1899.

Autonomous Currant Office. Bulletin of the Autonomous Currant Office [translated title]. Athens.

Eiswaldt, E. Die Wirtschaft Griechenlands. [The agriculture of Greece.] 184 p. Duncker und Humblot, München u. Leipzig. 1928.

[Greece] Official Gazette [translated title]. Athens.

Kromidakis, James K. The currant-grape industry with particular reference to the trade of the United States. 121 p. Berkeley. 1924 (Typewritten thesis [M.S.], University of California. December, 1924. On file in the University of California Library.)

nopoly in currant growing, but Australia now produces about one-tenth of the world output of currants.

The Greek currant crop is produced mainly on a strip of land running along the northern coast of the Peloponnesus, westward from Corinth to Patras, around the northwest corner and down the west coast, and on the islands of Zante and Cephalonia. The raisin crop, on the other hand, is grown mainly on the island of Crete. Because of soil and climatic conditions, the best of the seedless black currants produced in Greece probably have a better flavor than those produced in other countries.

The importance of the Greek currant industry to the well-being of the whole country is indicated by the fact that about half a million people are said to depend directly upon it for their livelihood. As to the additional number dependent upon raisin growing, there are no figures. Any crisis in the currant business is keenly felt by producers, because the entire livelihood of a large number of peasants, holding only from 2 to 12 acres apiece and specializing in currant production, depends upon this one crop.

PRODUCTION TREND

The production of currants in Greece amounted to only 147,000 tons in 1930, but since 1870 it has varied for the most part between 150,000 and 200,000 tons annually (table 5). Most of the output has been disposed of abroad since domestic demand and consumption have been small and utilization for wine and alcohol has not given a remunerative return to growers. During the past ten or fifteen years, largely because of the policy of restriction, production has been smaller on the whole than in earlier years, and a smaller portion of the crop has been exported.

The available estimates of currant acreage in Greece for the years 1915 to 1929[9] appear to be quite unreliable even as an indicator of the trend of production. They differ greatly from year to year in an obviously inconsistent manner, showing, for example, 157,000 acres in 1923, about 194,000 in 1924, and about 180,000 in 1925. The estimates for the four years 1926–1929 appear relatively more consistent although their accuracy is questionable. Acreage data show a downward trend somewhat in line with that indicated by the production estimates in table 5, decreasing from about 159,000 acres in 1926 to about 147,000 acres in 1929. The four-year average is approximately 152,000 acres while the corresponding average annual production indicated by table 5 is about 148,000 tons. Calculations based on these figures indicate an

[9] Acreage data 1915–1928 in: Statistique Annuelle du Rendement Agricole de la Grece; and 1929 in: Internatl. Yearbook of Agr. Statis. 1929–30.

average yield of somewhat less than 1 ton per acre, which corresponds closely to Simpson's[10] estimates in 1923 of a normal yield of something under 1 ton per acre, probably about $\frac{9}{10}$ ton.

TABLE 5

GREEK PRODUCTION AND EXPORTS OF CURRANTS FOR SPECIFIED YEARS, 1870–1891, ANNUAL 1893–1933

Year	Production*	Exports†	Year	Production*	Exports†
	short tons	*short tons*		*short tons*	*short tons*
1870	58,190	61,893	1910	133,837	128,547
1876	97,759	87,285	1911	176,686	126,748
1878	111,090	108,445	1912	182,505	134,895
1881	140,185	140,450	1913	171,925	131,245
1888	178,802	171,713	1914	158,700	131,192
1891	181,976	171,555	1915	134,895	110,561
1893	185,679	167,693	1916	97,865	56,603
1894	167,693	163,461	1917	126,960	27,508
1895	198,904	186,208	1918	126,960	110,720
1896	174,570	158,171	1919	136,482	116,539
1897	198,375	123,786	1920	145,475	94,215
1898	189,382	153,410	1921	129,605	104,213
1899	160,816	138,069	1922	128,547	85,645
1900	51,842	55,016	1923	105,800	100,246
1901	158,700	137,011	1924	178,802	95,061
1902	178,273	145,475	1925	171,925	94,638
1903	205,781	129,605	1926	148,914	91,993
1904	170,338	135,424	1927	142,618	95,802
1905	180,918	127,489	1928	155,900	77,528
1906	152,352	122,199	1929	143,400	77,702
1907	175,628	141,243	1930	147,400	85,596
1908	210,542	121,141	1931	73,700	70,759
1909	207,897	135,424	1932	144,000	76,558
			1933	114,000‡	——

* Calendar year in which harvested.

† Export seasons extending from September 1 of year indicated to August 31 of the following year.

‡ Preliminary estimate. About 50,500 tons were so damaged by rain as to be unfit for export, 25,700 were slightly damaged, and 37,800 undamaged.

Sources of data:

Data on production and exports for years 1870 to 1922 from: Documentary Report to the bill regarding the Autonomous Currant Office, Athens, June 12, 1924. (Data from Struck, Adolf, Zur Landeskunde von Griechenland, p. 101, 174. Heinrich Keller, 1912, appear to be roughly comparable with other production data in this table.)

1923 to 1928: from Greek Legation, Washington, D. C.

1929 to 1933: from U. S. Agr. Commissioner N. I. Nielsen, Marseilles, France. The official Greek Government statistics given in the publication, "Statistique Annuelle Agricole de la Grece," also give currant production figures, but because the Autonomous Currant Office is in such close touch with the currant situation, figures issued by the latter probably give a clearer picture of the situation than do the government figures. The figures from the Greek Legation are furnished by the Autonomous Currant Office.

EXPORTS AND EXPORT MARKETS

The leading export markets for Greek currants are the United Kingdom, Germany, the Netherlands, the United States, and Canada (see tables 6 and 7). Exports, however, have undergone a rather decided decline since 1919. In the principal markets the Greek currant has lost

[10] Simpson, John L. Greek currant situation. p. 11–12. (Typewritten report to Sun-Maid Raisin Growers Association covering observations in Greece from August 24 to September 15, 1923.) Mr. Simpson believed that the currant acreage of Greece in 1923 was roughly about 150,000 acres.

much ground since the World War on account of a growing preference by consumers for the small seedless raisin which, for many purposes, can be used in the place of the currant.

The British Market.—The chief consumer of Greek currants is the United Kingdom, which, for many years, has taken from 60 to 80 per cent of Greek exports. Since the War, however, British imports of cur-

TABLE 6

GREEK EXPORTS OF CURRANTS BY COUNTRIES OF DESTINATION, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar years	Total	United Kingdom	Netherlands	Germany	United States	Canada	Italy	France	Belgium	Other countries
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average:										
1909–1913	233,238	121,268	29,457	28,779	29,705	*	*	4,412	1,903	17,714
Annual:										
1920	211,938	126,923	10,267	4,020	63,115	1,266	488	4,308	697	854
1921	195,833	105,808	21,044	8,891	47,930	2,539	1,390	3,032	1,384	3,815
1922	160,659	107,740	20,853	2,330	21,672	1,581	638	4,090	1,440	315
1923	241,831	186,290	21,048	7,715	20,345	2,315	1,357	1,753	592	416
1924	205,965	123,532	34,356	22,996	15,282	1,754	3,551	1,629	1,083	1,782
1925	176,854	111,825	18,969	16,263	16,389	1,847	7,406	1,400	450	2,305
1926	177,488	114,209	20,674	15,726	14,997	1,482	7,550	1,313	351	1,186
1927	180,350	120,677	18,967	17,998	10,160	839	7,313	3,011	512	873
1928	179,483	124,118	14,849	18,467	11,358	817	7,388	1,433	331	722
1929	151,703	99,459	17,483	14,802	9,387	104	7,568	1,124	198	1,578
1930	160,927	109,468	17,910	12,749	9,206	187	6,460	1,140	399	3,408
1931	146,361	95,389	19,645	16,387	6,693	*	3,009	981	79	4,178
1932†	155,995	103,627	23,580	14,531	6,746	*	4,123	1,153	*	2,235

* Included in "other countries."

† Preliminary data subject to revision.

Sources of data:
Data through 1928 from: Statistique du Commerce Special avec les Pays Etrangers. 1929-1932 from Bulletin Mensuel du Commerce Special de la Grece avec les Pays Etrangers. December issues.

rants from Greece have declined largely because of increasing competition from both currant and raisin supplies from other producing countries (table 8). Since 1920, United Kingdom imports from Australia have increased from a normal of less than 1 per cent to about 15 per cent of total currant imports. Rapid expansion of raisin production in both California and Australia during the past decade has naturally resulted in low prices and a big increase in British imports from these two producing areas. Moreover, since 1924, importation of Australian raisins into the United Kingdom has been stimulated by the preferential customs duty of 7 shillings a hundred weight of 112 pounds (the equivalent of 1.5 cents a pound at par exchange) granted them in 1925. On November 17, 1932, the duty was raised to 10 shillings 6 pence, the equivalent

of 2.3 cents a pound with sterling at par, but considerably less at the exchange rates prevailing at that time.

Increasing competition from raisins has been an important factor in

TABLE 7

CURRANT IMPORTS INTO PRINCIPAL IMPORTING COUNTRIES, BY COUNTRY FROM WHICH IMPORTED, CALENDAR YEAR AVERAGES, 1909–1913, 1921–1925, AND 1926–1930

Importing country and years	Country from which imported			Importing country and years	Country from which imported		
	Total	Greece	Australia		Total	Greece	Australia
	1,000 pounds	*1,000 pounds*	*1,000 pounds*		*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom:*				New Zealand:			
1909–1913	139,706	139,171	†	1909–1913	2,626	1,767	137
1921–1925	136,589	124,395	11,968	1921–1925	1,402	430	959
1926–1930	129,981	112,519	17,187	1926–1930	1,311	269	1,017
Germany:				Union of South Africa:			
1909–1913	36,342	35,412	†	1909–1913¶	1,851	1,213	69
1921–1925	12,678	12,527	†	1921–1925	867	223	628
1926–1930	21,849	21,845	†	1926–1930	974	565	398
Netherlands:				Denmark:			
1909–1913	26,389	25,917	†	1909–1913	757	362	†
1921–1925	24,929	23,508	†	1921–1925	677	333	†
1926–1930	23,104	23,040	†	1926–1930	584	332	†
United States:				Poland:			
1909–1913‡	32,559	32,229	0	1909–1913	**	**	**
1921–1925	26,021	25,328	136	1924–1925§	258	95	†
1926–1930	10,890	10,628	54	1926–1930	1,211	903	†
Canada:				Sweden:			
1909–1913	11,590	9,374	†	1909–1913	232	86	†
1921–1925	5,762	4,514	153	1921–1925	277	124	†
1926–1930	5,208	1,325	3,728	1926–1930	340	152	†
Irish Free State:*				Czechoslovakia:			
1924–1925§	7,789	2,569	†	1909–1913	**	**	**
1926–1930‖	7,420	3,455	†	1921–1925	89	20	†
				1926–1930	167	136	†

* The Irish Free State is included with United Kingdom previous to April, 1923.

† Few, if any. Outside of British countries, currant imports are nearly all of Greek origin, although not always imported directly from Greece.

‡ Year beginning July 1.

§ Two-year average, 1924-1925.

‖ Four-year average.

¶ Includes raisins.

** Data not available.

Source of data:

Compiled from official sources by the Foreign Agricultural Service of the U. S. Department of Agriculture. Data for 1930 in some instances may be preliminary and therefore the 1926-1930 average may be subject to minor changes.

restricting British imports of Greek currants. In the years 1909 to 1913, the imports of Greek currants into the United Kingdom averaged approximately 139,000,000 pounds annually, while net imports of raisins

from all countries averaged nearly 79,000,000 pounds. Up to 1926 currants from Greece and Australia continued to be imported into Great Britain in larger quantities than raisins with the exception of the one year, 1922. Since 1925 raisin imports have exceeded currant imports by a considerable margin.

TABLE 8

UNITED KINGDOM IMPORTS* OF CURRANTS AND RAISINS, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Currants			Raisins, total
	Greece	Australia	Total†	
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average:				
1909-1913	139,171	—‡	139,705	80,733
Annual:				
1920	136,089	935	138,959	75,538
1921	108,084	4,525	112,869	81,552
1922	107,610	8,995	116,845	131,076
1923	160,979	10,586	172,033	126,519
1924	129,764	20,511	150,337	130,888
1925	115,540	15,224	130,863	126,272
1926	113,633	16,962	130,731	130,164
1927	126,269	10,789	137,140	178,331
1928	122,631	1,390	124,253	156,127
1929	96,410	26,835	123,549	179,478
1930	103,652	29,959	134,234	153,733
1931	94,355	23,431	118,248	139,059
1932§	106,840	20,584	127,424	187,958

* Data are for gross imports, i.e., reëxports have not been subtracted.

† The total imports of currants include small quantities imported from countries other than Greece and Australia.

‡ Imports for Australia not reported separately but were very small.

§ Preliminary data subject to revision. Data on imports of currants from Greece and Australia include small quantities imported from other foreign countries and other British countries.

Sources of data:
Compiled from Annual statements of the trade of the United Kingdom with foreign countries and British countries except data for 1932 which are from monthly accounts relating to the trade and navigation of the United Kingdom for December, 1932.

It appears that the rapid extension of raisin consumption since the War has undoubtedly checked the further growth of the currant industry and has perhaps actually made some inroads into it. However, no rapid displacement of currants by raisins is apt to occur in the British market, for currants will undoubtedly continue to be preferred to raisins for many of the uses to which they have heretofore been put.

The Netherlands and German Markets.—The second and third most important direct export markets for Greek currants are the Netherlands and Germany, respectively. During the period 1909–1913, Germany took, on an average, about 35,412,000 pounds of Greek currants annually and the Netherlands an average of 25,917,000 pounds annually.

In the years 1926–1930 German imports of Greek currants averaged 21,845,000 pounds annually and the Netherlands averaged 23,040,000 pounds annually (see table 7). All of the German imports of currants come from Greece. The Netherlands, however, in addition to the annual average of 22,789,000 pounds imported direct from Greece, also imports small quantities of currants from the United Kingdom and Germany, which are undoubtedly of Greek origin transshipped from British and German markets.

TABLE 9

GERMAN IMPORTS OF CURRANTS AND RAISINS, AVERAGE 1909–1913, ANNUAL 1922–1932

Calendar year	From Greece		Total raisins from all countries*
	Currants	Raisins*	
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
Average:			
1909–1913	35,412	1,662	39,900
Annual:			
1922	2,489	677	3,464
1923	2,556	1,196	7,937
1924	22,708	6,439	50,795
1925	22,059	10,907	55,402
1926	20,757	10,506	59,306
1927	23,608	9,728	61,451
1928	22,289	13,102	74,218
1929	21,413	13,597	76,032
1930	21,158	14,147	78,540
1931	18,231	13,488	75,758
1932	19,165	11,318	79,069

* Does not include cluster raisins.

Source of data:

Monatliche Nachweise über den Auswärtigen Handel Deutschlands.

While the Dutch and German imports of currants since the War have remained at a relatively stable level, there has been a rapid increase in imports of raisins into both markets. In Germany the raisin imports are now normally about three times those of currants, while in the Netherlands, raisin imports have only recently come to exceed those of currants (tables 9 and 10). German imports of raisins in 1930 amounted to 78,540,000 pounds, while raisin imports into the Netherlands amounted to 24,329,000 pounds (table 10). In Germany and the Netherlands, as well as in several other Continental European countries, consumption appears to depend primarily on price rather than quality or other factors, the bulk of the demand being for whichever product—raisins or

currants—is cheaper.[11] The average housewife in these countries is very economical in using raisins. However, raisins are gradually coming into use in everyday cooking and not merely as a luxury ingredient in cakes. For use in puddings and other combination dishes, when raisins are cheaper than currants, their larger size frequently gives them preference over currants.

TABLE 10

NETHERLANDS IMPORTS OF CURRANTS AND RAISINS, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Currants		Raisins		
	From Greece	Total currants*	Sultanas from Greece	Total sultanas	Total, all raisins
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average:					
1909-1913	25,917	26,389	†	†	10,931
Annual:					
1920	13,991	14,854	666	3,843	—‡
1921	21,823	25,362	735	6,397	9,162
1922	21,806	23,739	2,443	5,362	7,615
1923	24,491	25,470	1,792	14,996	18,768
1924	29,493	29,850	1,964	17,919	20,798
1925	19,927	20,218	881	10,388	12,617
1926	25,410	25,549	639	13,653	16,264
1927	27,229	27,270	437	16,722	18,946
1928	19,019	19,057	600	24,449	26,535
1929	22,350	22,443	410	27,957	29,845
1930	21,186	21,210	299	22,408	24,329
1931	22,375	22,758	263	22,415	24,394
1932§	22,553	22,626	—	22,015	23,849

* Includes imports from the United Kingdom and Germany which undoubtedly are of Greek origin.
† Imports of sultana raisins separately are not available for years 1909–1913.
‡ Dashes indicate data not available.
§ Preliminary data subject to revision.

Source of data:
Nederland Jaardstatistiek van den in-uit-en door voer, and Nederland Maandstatistiek von den in-uit-en door voer, December issue.

The American and Canadian Markets.—Before the War, the United States was an important export market for Greek currants, imports directly from Greece having averaged 32,229,000 pounds annually during the five years 1909–1913 (see table 11). Since the War, however, imports of Greek currants have averaged only 10,628,000 pounds annually (1926–1930). It is obvious, therefore, that the Greek currant trade has suffered a serious reversal in the American market in recent years, imports now amounting to only about a third of the pre-war total.

[11] In this connection it may be mentioned that on these markets especially, the prospect for Greek currants is dependent upon the quality of the Smyrna Sultana crop. If this, as often happens, is damaged by rain, it is sold at a very low price and a dull currant market is the result. This is especially true if the Greek fruit of which Germany and the Netherlands import mainly lower grades, is of poor quality, as it has been in recent years.

In the Canadian market much the same thing has occurred. In the period 1909–1913 Canada imported an average of 9,374,000 pounds of currants annually directly from Greece (see table 12), but in the years 1926–1930 only 1,325,000 pounds annually. Not only have Canadian imports of Greek currants declined materially but total Canadian imports

TABLE 11

UNITED STATES IMPORTS OF CURRANTS BY COUNTRIES OF ORIGIN, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Greece	Australia	Other countries*	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average:				
1909-1913†	32,229	—‡	—	32,559
Annual:				
1920	54,229	26	1,577	55,832
1921	55,387	153	1,547	57,087
1922	20,822	157	459	21,438
1923	23,009	140	325	23,474
1924	13,624	118	223	13,965
1925	13,796	109	287	14,192
1926	12,772	64	480	13,316
1927	11,597	115	239	11,951
1928	10,386	22	259	10,667
1929	9,697	53	52	9,802
1930	8,688	16	12	8,716
1931	6,420	6	0	6,426
1932	7,150	62	5	7,217

* Imports from "other countries" are probably of Greek origin though imported from, i.e., via the United Kingdom, Italy, Canada, and some other countries.

† Years beginning July 1.

‡ Dashes indicate data not available.

Sources of data:
U. S. Dept. Com. Foreign Commerce and Navigation of the United States, annual issues.

of currants are now only about half of what they were before the War. In 1925 Canada granted free entry to Australian currants, which had previously been dutiable at ⅔ cents a pound. This materially stimulated exports of currants from Australia to the Canadian market. As a result, Australia has now largely replaced Greece as a source of supply for currants. Moreover, the total decline in the Canadian imports of currants has been offset by increased imports of raisins, which in a number of recent years have been nearly double the pre-war average.

The New Zealand Market.—New Zealand was an important export market for Greek currants before the War, imports of currants during the period 1909–1913 averaging 2,626,000 pounds annually, practically all from Greece (see table 13). During the five years 1926–1930 the

TABLE 12

CANADIAN IMPORTS OF CURRANTS BY COUNTRIES OF ORIGIN AND TOTAL IMPORTS OF RAISINS, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Currants				Raisins
	Greece	Australia	Other countries*	Total	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average:					
1909-1913	9,374	—†	2,216	11,590	22,331
Annual:					
1920	4,453	136	1,113	5,702	35,879
1921	6,046	43	1,214	7,303	24,833
1922	2,798	33	1,409	4,240	31,849
1923	5,122	210	1,049	6,381	37,536
1924	4,345	140	1,084	5,569	46,785
1925	4,260	340	716	5,316	31,681
1926	3,398	688	494	4,580	40,854
1927	1,260	4,824	40	6,124	41,400
1928	1,179	5,428	25	6,632	44,594
1929	366	3,987	168	4,521	40,824
1930	422	3,712	47	4,181	35,636
1931	388	4,471	6	5,865	36,700
1932	121	5,596	3	5,720	40,602

* Imports from "other countries" are probably of Greek origin although imported from, i.e., via the United States, the United Kingdom, and some other countries.

† Dashes indicate data not available.

Source of data: Monthly and Quarterly Reports of the Trade of Canada.

TABLE 13

NEW ZEALAND IMPORTS OF CURRANTS BY COUNTRIES OF ORIGIN AND TOTAL IMPORTS OF RAISINS, AVERAGE 1909–1913, ANNUAL 1921–1932

Calendar year	Currants				Raisins
	Greece	Australia	Other countries*	Total	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average					
1909-1913	1,767	137	722	2,626	4,681
Annual:					
1921	163	182	0	345	4,299
1922	273	1,349	19	1,641	6,212
1923	243	1,302	8	1,553	6,930
1924	605	1,190	28	1,823	8,266
1925	848	790	12	1,650	8,050
1926	336	635	79	1,050	9,044
1927	280	1,148	27	1,455	9,394
1928	241	1,039	5	1,285	9,009
1929	315	1,146	8	1,469	9,651
1930	170	1,114	10	1,294	7,980
1931	108	1,524	0	1,632	9,611
1932	90	1,326	3	1,419	10,394

* Imports from "other countries" are probably mostly reëxported Greek currants.

Source of data:
Statistical Report on Trade and Shipping of New Zealand, and Monthly Abstract of Statistics.

currant imports from Greece averaged only 269,000 pounds annually (table 7). Greece has lost ground in this market by the competition from Australian currants and California seedless raisins. Imports of currants have declined as compared with the pre-war period, while the raisin imports have steadily increased. New Zealand imports of raisins averaged 4,681,000 pounds annually during the period 1909–1913. In 1929 she imported 6,112,147 pounds of raisins from the United States alone, and 9,651,000 pounds from all foreign sources.

TABLE 14

ARGENTINE IMPORTS OF CURRANTS AND SULTANAS FROM GREECE AND OF RAISINS FROM THE UNITED STATES, 1925–1931

Calendar year	Greek currants and Sultanas	California raisins
	1,000 pounds	*1,000 pounds*
1925	228	418
1927	177	767
1928	222	1,575
1929	125	1,458
1930	25	1,764
1931	60	1,313

Sources of data:
1925–1929 from: report of the United States Trade Commissioner M. T. Houghton.
1930 and 1931 from: Anuario del Comercio Exterior de la Republica Argentina.

Other Foreign Markets for Greek Currants.—South American and Far Eastern markets have taken very few Greek currants up to the present time. An effort is being made to develop the trade both in the South American countries and in the Far East, but competition from California, Spanish, and Australian raisins presents a formidable obstacle. The currant is too expensive for these markets, which, moreover, seem to prefer the sweeter flavor of the raisin to the somewhat tart flavor of the currant.

Among the separate countries in this group, Argentina is the most important. The Argentine import figures in table 14 indicate that imports of Greek currants have scarcely been holding their own in recent years, whereas imports of raisins from the United States have markedly increased.

Export Outlook.—It appears that the sultana raisin has proved to be a greater menace to the currant industry of Greece than has direct competition from the currants produced in Australia. It is doubtful whether the Greek currant will be able to regain its former position. Although there will probably always be a demand for large quantities of currants,

consumption will probably not increase much unless currant prices become considerably lower than raisin prices. However, overproduction already exists in the Greek currant industry. Prices therefore have been low for several years, so that a large increase in foreign consumption could hardly occur unless marked economies in costs of production are effected that make lower prices profitable to growers. This appears rather unlikely. With world production of raisins also tending to exceed world demand, it would appear that currants will be doing exceedingly well to hold their own in world competition.

EARLY DEVELOPMENT OF GOVERNMENT AID[12]

As long as the Greek currant-growing areas were under the Turkish government the industry made no progress. After the war of independence (1821–1829), however, a rapid development took place under the influence of the land-settlement laws of 1835 and 1879. In 1877 a new economic factor began to play a very important role. The bulk of French vineyards were destroyed by phylloxera and there was consequently a great demand for imported currants to be used in wine-making. From a relatively unimportant currant market, France became the chief one, and her imports increased between 1877 and 1889 until they accounted for over half of the Greek crop. Greek producers invested their capital in extensive new plantings.[13] Between 1876 and 1893 production rose from 98,000 tons to 186,000 tons (see table 5). After the reëstablishment of the French vineyards by the introduction of resistant American vines the French market soon disappeared, and French wine growers insisted on protection from the competition of imported currants.

Greece has ever since been confronted with the difficult problem of marketing her surplus currants. The increase of world population during the last fifty years has afforded little relief because competitive raisin industries in California, Smyrna, Spain, South Africa, and Australia have diverted most of the potential world demand from currants to raisins.

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12 Concerning the history of the attempts to aid the Greek industry, see: Eisen, Gustav. The raisin industry. H. S. Crocker and Company, San Francisco. 1890; and Kipps, J. The Greek currant trade. Econ. Hist. (a supplement of the Economic Journal) 2(5):137. 1930. Much of what is said herein concerning this subject is drawn from these sources.

13 "Instead of using their profits to pay off debts, the peasants invested all available capital in new plantations, and in the speculative mania the quality of the vineyards was neglected; for it had become profitable to plant poor quality but large-bearing vines. Currants displaced all other crops, olives were cut down and pastures turned into vineyards." Kipps, J. The Greek currant trade. Econ. Hist. (a supplement to Economic Journal.) 2(5):140. 1930.

The First Retention Law (1895) and Subsequent Revisions.—With prices remaining ruinously low the pressure for government intervention on behalf of the growers became irresistible. After consideration and rejection of the idea of restriction of production[14] the Retention Act was passed in 1895. This Act provided that every exporter should deliver 15 per cent of his intended exports to a government warehouse, without remuneration, or else pay the equivalent of this amount in cash. The retained currants were to be used within the country, for industrial purposes only (wine and industrial alcohol) and no other substance but currants and grapes was to be used for these purposes.

This measure was expected to raise prices by creating an artificial shortage on the foreign market. The law was based on the unique position of the Greek industry, i.e., the fact that virtually the whole crop was exported, and that these exports constituted almost the entire world supply. Whether paid in cash or in kind, the retention requirement operated virtually as an export tax. Exporters continued to glut the market, however, by paying cash to the government and exporting the fruit, so that in 1896 the cash provision of the law was repealed. Another amendment, passed in 1899, provided that the quota be fixed yearly by an official committee according to variations in the size of the crop, with the quota limits ranging, however, from 10 to 20 per cent. The retention currants were sold by the government to wine makers and distillers, and the profit was accumulated and used to establish the "Currant Bank" in 1899. This bank was to make loans to growers at a low interest rate of 6 per cent. Every grower was a shareholder of this bank and the size of the loans a grower could obtain depended on the volume of his sales.

This legislation was followed by further increase in acreage and production. Under the prevailing arrangement the bother of disposing of from 10 to 20 per cent of his surplus crop was entirely removed from the grower; and the more he sold in one season, the greater was the advance he could obtain in the next for carrying on his business.

A further increase in the retention quota was not sufficient to maintain prices. The government, therefore, undertook to pay a fixed minimum price for all currants offered to the Currant Bank. Loans were made to the Currant Bank for financing storage and marketing. It hap-

[14] "The suggestion to restore equilibrium by a restriction of production was not popular. Restriction on a cartel system by a mutual agreement of quotas would be obstructed by the smallness of the units of production, the difficulty of forecasting the size of the crop, the illiteracy of the peasants, and the complete absence of organization among them. The obstacles confronting an attempt to organize the growers were large and numerous. The Greek was said to be temperamentally opposed to combination and mistrustful of his neighbors. . . ." Kipps, J. The Greek currant trade. Econ. Hist. (a supplement of the Economic Journal) 2(5):141. 1930.

pened, however, that the fixed price was better at that time than the market price. As a result warehouses became overstocked and the Bank suffered ruinous losses.

The price-fixing scheme was accordingly dropped and a government monopoly was considered, the situation having meanwhile become more serious as a result of the bumper crops in 1902 and 1903. The monopoly, however, was protested by England, Germany, and the Netherlands, because it was not in harmony with the commercial treaties between Greece and those countries. The retention, therefore, was taken up again in 1904. With a 20 per cent retention, and with a 15 per cent export tax which (formerly paid in cash) had to be delivered in kind, the retention quota now actually amounted to 35 per cent of the quantity exported. New plantings were made impossible by a heavy tax on increasing acreage. But new difficulties arose. In addition to its large immediate obligations, the Currant Bank, after several years of existence, found that it had almost as many requests for loans as there were currant growers. Moreover, its warehouses were full of currants which could not be disposed of, amounting to about 200 million pounds. The situation naturally became financially impossible, and the Currant Bank failed.

THE PRIVILEGED COMPANY, 1905–1925

Under the foregoing conditions the government saw no other solution than to take up a kind of monopoly scheme again. This time a private joint stock company, "The Privileged Company for the Protection of Currant Production and Trade," was created by the law of July 30, 1905. The essential difference between this institution and the former Currant Bank was that the shareholders of the latter were only Greek peasants, while the shareholders of the Company were mostly foreign capitalists. The charter was valid for twenty years. The new law provided that the Company should retain in kind 35 per cent of the intended exports, to be used within the country for industrial purposes, and prohibited the making of wine and alcohol from materials other than grapes and currants. In order to support the Company's activity the prohibitive tax on new plantings was continued and the government obligated itself not to reduce taxes on alcoholic liquors imported into Greece nor to impose any export duty on Greek alcoholic drinks.

Functions of the Privileged Company.—In return for the privilege of receiving great quantities of currants without paying for them, the Company had to pay in advance the land tax from which the grower was freed, though the grower still had to pay to the Company a special tax on all currants produced. It also undertook to conduct an advertising

campaign for increased consumption of currants, but this never got very far. Up to 1914 the Company was also obliged to pay a fixed price for any currants offered to it during the crop season, and to guarantee a fair minimum price for purchases made at the end of the season. The Company was given the exclusive right of warehousing currants and was required to grant loans to growers at the low interest rate of 6 per cent.

Difficulties and Criticisms.—As a result of heavy crops, in 1908 and 1909 the Privileged Company passed through a crisis from which it emerged only with the help of an "uprooting" law in 1910. A government loan was granted to the Company with which to compensate the owners of the 47,000 acres of currants which were destroyed from 1910 to 1913 under the "uprooting" law. In spite of these, and, subsequently, other measures of assistance by the government, the Company made an average profit of only 1.8 per cent during the first nine years of operation (1905–1914). The Wine and Spirits Company, organized to manufacture the retained currants into wine and alcohol, made large profits from the low-priced currants sold to it by the Privileged Company, but these profits did not go to the growers.

The Privileged Company was criticized continually on the grounds that it thought only of profit-making by decreasing production and by other manipulations, and that it did nothing to stimulate the consumption of currants in the world or to improve the wasteful marketing and unhygienic packing methods. Growers felt that they were not helped at all by its functions. In 1925 the twenty-year charter of the Privileged Company was to expire; and when it came time to consider renewal the official report on the record of the Company proved to be so critical that the government at once gave up all idea of renewing the charter. Throughout the last year of the old charter the government actually took over the functions of the Privileged Company and contracted with the National Bank for financial assistance in the complete management of the industry for one year.

THE CENTRAL CURRANT OFFICE

A new law enacted in 1925, creating the Autonomous Central Currant Office, was a wide departure from earlier legislation, in that it placed the regulation of the industry in the hands of a large central coöperative association of the growers. Earlier government intervention had been necessitated partly because of the lack of organization or coöperative spirit among the growers, but by 1925 coöperation had made such pro-

gress that it was now possible for the first time to organize the industry on a coöperative basis.[15]

In establishing the Central Currant Office the government was faced with difficult problems of policy and organization. It was decided that the new organization should represent the entire currant industry and should not be a mere private corporation organized for profit. Since it did not seem feasible to establish a coöperative organization with sufficient membership to control disposal of the entire crop, the government solved the problem by establishing a nonprofit association, the Central Currant Office, endowing it with monopoly powers with a minimum of government participation in its conduct. The promoters of the plan had in mind such institutions as the German sugar cartels and similar British organizations for agricultural produce. The Central Currant Office has no shareholders; it is owned by nobody; it is autonomous.

Organization and Function.—The organization of the Central Currant Office is such that the growers, who had no influence in the business matters of the Privileged Company and were said to have been exploited by it, now take part through their coöperatives in outlining the policies affecting their industry. Eight delegates to an Administrative Council are elected for three years from the Unions of Agricultural Coöperative

[15] The rapid growth of the coöperatives was due to changed conditions during and following the War. The war-time military discipline, agricultural prosperity during and immediately after the War, better loan facilities, and other factors, all helped to stimulate the growth of coöperation to the point where most of the currant growers now belong to coöperatives.

Earlier legislation had definitely encouraged the growth of coöperatives; and subsequent legislation has continued this policy. A decree of May 29, 1920, created a council of agricultural coöperative societies, composed partly of government officials and partly of representatives of the coöperatives, empowered to give its opinion on all questions regarding coöperative matters, particularly the granting of credit. A decree of March 23, 1923, dealt with the reconstruction of coöperative societies of farmers. When the government in 1924–25, coöperating with the National Bank, went to the assistance of the currant and raisin industry, associations of growers were granted loans from the government at lower interest rates than were individual producers. Later on, when the duty-free entry of agricultural equipment, which had been in effect since 1914, was abolished, the coöperatives, especially those of currant growers, were favored by the decree of December 22, 1928, which allowed them importation of sulfur, copper sulfate, and fertilizers, free of duty. In the fall of 1929, the National Bank, coöperating with the Central Currant Office made loans on currant mortgages at a better rate to coöperatives than to individual producers or merchants. Early in 1930, the Central Currant Office decided to buy up to 5,290,000 pounds of the lower-grade currants for the purpose of stabilizing the market, but only from coöperatives.

Other laws passed in 1926 and 1929 have given government aid to mutual insurance coöperatives, particularly those insuring against hail and frost damage. These and other measures indicate the importance which the government has in recent years attached to coöperative action as a method of improving the condition of the currant industry, as of other branches of domestic agriculture. The coöperatives, of which there are today over 900 in the currant industry, with 30,000 members, undertake, besides commercial transactions, coöperative wholesale supply of necessary materials and credit.

Societies, from coöperatives not belonging to the Union, and from the unorganized producers. In addition, the grape growers have one representative on the Council, currant exporters two (elected by the Chambers of Commerce), and the government has four delegates from the Ministries of Agriculture, Finance, National Economy, and the National Bank. A managing director is the sixteenth member of the council and chairman; the council elects a committee of three to manage the Central Currant Office. The ministerial representation on the council is provided for in order to give expert advice and also because of the government's interest in the export tax. The administration in general, however, is as far removed as possible from the civil service.

The more important prescribed activities of the Central Currant Office are as follows:

1. The establishment of a balance between supply and demand by retention, or by purchase at fixed prices according to the grade or variety, of surpluses in the open market and the handling and disposal of currant products coming in any way to the organization.

2. General insurance of the product against production risks, and the study and application of scientific means for the improvement and protection of quality, and for the reduction of the cost of cultivation.

3. The warehousing and classification of the currants in accordance with specified commercial standards for producers, coöperative organizations, or merchants.

4. Encouragement of greater consumption of currants through advertisement and other ways.

5. The systematizing and standardization of marketing methods.

6. Encouragement, through the coöperative organizations, of coöperative action in obtaining agricultural supplies for currant production.

7. The support of currant prices in foreign markets by a special system of export credits.

The Central Currant Office is exempt from taxes, postages, stamp duties, and similar charges. Financed at the beginning by the government, it has completely paid off these advances from profits made by the handling of the retained currants. The Central Currant Office is obliged to pay to the government, out of the gains by the retention, the general land tax on all currants produced, in place of direct payments of the tax by the growers themselves. It also imposes certain charges upon exporters (to be paid in British currency), besides a special export tax for defraying the expenses of the advertising campaign.[16]

[16] Besides the various local taxes there is a general tax upon exported currants, levied for the support of the agricultural advisory boards in the currant districts. These taxes are not connected in any way with the operation of the Central Currant Office.

Market Stabilization by Retention.—The retention scheme is inseparably connected with the operation of the Central Currant Office. The annual retention quotas fixed during the period 1926 to 1928 amounted to 50 per cent of the intended exports, but were reduced to 45 per cent for the 1929 and 1930 exports. For the export season 1930–31 the quota was again raised to 50 per cent. The determination of this percentage is based on the size of the crop and on the information which the Central Currant Office receives concerning the position of the world market. The United Kingdom is the chief consumer of Greek currants but the retention is not applied to its full extent, as regards that market. A special agreement with Greece on July 16, 1926, provided that there shall be left free for import into the United Kingdom a quantity determined on the basis of the average amount taken by the United Kingdom during the three preceding years, plus a margin of 5 per cent to allow for probable increase in consumption.

In order to prevent shipments of improperly prepared and low-grade fruit, the Central Currant Office is also authorized to fix the date for opening shipments to foreign countries. The retained currants are sold locally by the organization either for human consumption or for the manufacture of alcohol and industrial products like currant paste, etc. The Office has also been allowed in recent years to accept fresh currant grapes for immediate use in wine-manufacturing. In order to prevent their being worked into currants, it has paid a premium of about 65 cents a ton for them.

Marketing Under the Central Currant Office.—Under the operations of the Central Currant Office there is a regular open market for dealings in nonretention currants. Brokers, dealers, packers, and exporters are free to carry on their individual operations without interference. The Central Currant Office is not a selling agency monopolizing the whole production and marketing it abroad for its own account. It does not directly intervene between buyer and seller; neither does it attempt to fix prices at which the nonretention currants are sold or resort to any other method of direct regulation. Its price-fixing activities are confined, for the most part, to the indirect effects which it is able to exert. By creating an artificial scarcity of currants for export it enables the growers to obtain higher prices for the exportable part of their crop than they would otherwise obtain. This it does primarily through the retention system. There is, it is true, one exception. In addition to its retention activities, the Central Currant Office buys up, at a price announced at the beginning of the season, any nonretention currants not exported which remain on hand as a drag on the market (see also page 29). But

it does not interfere with growers or exporters in the disposal of the nonretention currants. Both are free to make the best terms they can.

Retention Bills.—For currants delivered to the Central Currant Office the grower or exporter receives a certificate, called the "retention bill." This is issued by the General Stores which acts as a warehousing agency for the Central Currant Office and which is authorized to receive currants and to issue certificates on its behalf. The exporter must present this retention bill to the customs authorities in order to be permitted to export an amount corresponding to the allowance made on the basis of the retention quota. It is then definitely retired and cannot be reused for the release of further export lots.

Producers are also allowed to deposit with the General Stores currants not suitable for export, such as rain-damaged fruit, fresh currant grapes, and residue from cleaning machines, and for these products the Central Currant Office also issues retention bills.[17] Moreover, in cases when the Central Currant Office buys an unexportable surplus on the open market, it issues certificates upon delivery of the currants which can be exchanged for cash when desired. Retention bills are also issued to growers who deposit their currants voluntarily with the Central Currant Office, and if some of these nonretention currants remain unexported, the growers may still have possession of certificates in such amounts.

Retention bills are necessary for the release of currants for export. They are transferable. Holders of them who make no export sales are permitted to dispose of them on the open market. Similarly, sellers who are able to export their entire stock of currants can purchase the necessary amounts. Unsold retention bills of a former export season may also be used during a subsequent season for the release of exports of the new crop, up to a certain date fixed by the Central Currant Office. Purchase of the retention bills on the open market is the general rule, because they are usually cheaper than the currants. Their value fluctuates, however, in accordance with the foreign demand for currants. If this is strong, the bills are in greater demand from exporters, and owners of them are accordingly able to obtain premiums which would be smaller or non-

[17] Differences in quality of currants are taken into account by expressing the weight of the currants credited on the retention bill in terms of sugar content. That is to say, the number of Venetian pounds (1 Venetian pound = 1.058 pounds) entered on each bill for a given amount of fresh currants is determined by sugar content. Persons who deliver residue receive bills for an amount of currants proportionate to the weight of the sugar content of the residue. Discounts in the weight entered on the retention bill, as compared with the actual weight of the delivered currants, are made in case of currants not suitable for export; i.e., not sufficiently dried or cleaned. For good currants bought or offered for sale to the Central Currant Office the actual weight is represented on the bill rather than the discounted.

existent if the foreign demand for currants were weaker. The bills are also used as security for loans. The Central Currant Office grants loans on them through the medium of the National Bank, at a lower interest rate than that usually charged by the Bank.

Influence of "Intervention" Purchases on Prices.—Broadly speaking the prices received for exported currants are determined by the extent of the foreign demand, interacting upon the supply available for export under the retention system, and hence, so far as the operations of the Central Currant Office are a factor, the retention itself is the basic price determinant. But the amount of the retention having been predetermined, a further factor influencing export prices is the level at which the Central Currant Office sets the intervention price, that is, the price it will pay in the open market for unexportable surpluses during the course of, or at the end of, the season. This is a delicate task. For if the announced price is too high the incentive to find customers abroad and to close sales with them will be diminished. If, on the other hand, it is too low, sales abroad may be consummated at unnecessarily low prices simply because of fear on the part of exporters that they will be left with stocks which they cannot profitably dispose of at home. The task of the Central Currant Office, therefore, is to set its price for such surplus stocks from time to time at a point low enough to assure active export operations, and yet high enough to strengthen the bargaining position of the exporter. In a sense, therefore, the intervention price is in the nature of an indicator of basic price upon which owners of currants are able to count.

The manner in which changes in the general market situation from year to year influence both the open market spot quotations and the prices set by the Central Currant Office at the beginning of the season (late July or early August) for its open market purchases of surplus currants, is shown in table 15.

It will be observed that the Central Currant Office prices of surplus currants declined relatively about the same from 1929 to 1930 as the spot price of currants at Patras (except for one grade which was not a surplus grade). It is also to be noted that the Central Currant Office quotations for the lower grades and the retention bill quotations correspond rather closely with the spot prices of the lower grades at Patras. In view of what has been said above it is reasonable to suppose that this is more than a mere coincidence; that, once the Central Currant Office prices for surplus currants have been set, these tend to fix the minimum limits of spot quotations.

Sanitary and Packing Regulations.—The Central Currant Office is helped in its marketing activities by legislative measures to improve and protect the quality of the produce. Harvesting before a date which is

TABLE 15

SPOT PRICES OF CURRANTS AT PATRAS AND CENTRAL CURRANT OFFICE'S OPENING PRICE OF SURPLUS CURRANTS, SEASONS 1929–30 AND 1930–31

Classification	1929–30	1930–31	
	Cents per pound*	Cents per pound*	Per cent of 1929–30 price
Opening surplus price			
Aighialis and Corinth regions	3.87	2.83	73.1
Patras, Elias, Trifylias, and Zante regions	3.69	2.70	73.2
Other regions	3.56	2.58	72.5
Retention-bill quotations			
Retention bills	3.50	2.46	70.3
Spot prices† at Patras			
Class I:			
Quality A—Region, very fine, f.o.b. Vostizza	6.27–7.13‡	8.36–8.85‡	128.4‡
Quality B—Gulf, choice and fine	4.91–4.98	3.69–4.05	78.3
Class II:			
Quality A—Patras sun-dried	4.68	2.95–3.32	67.0
Quality B—Amalias	4.67	2.70–2.95	60.5
Class III:			
Quality A—Pyrgos	4.05	2.64–2.70	65.9
Quality B—Provincials	3.90	2.64–2.70	68.5

* Prices per Venetian pound converted to prices per pound avoirdupois by dividing by 1.058.

† Prices on November 30 of each season.

‡ It will be noted that prices of Class I, Quality A currants, do not move in harmony with those of the other grades. As there is no surplus of this grade, the prices it commands are independent of those received for the surplus grades.

Sources of data:

Opening surplus prices are from U. S. Agricultural Commissioner, N. I. Nielsen, Marseilles, France. January 13, 1931. Spot prices at Patras are from United States Consul, Franklin Yeager, Patras.

fixed by the Central Currant Office is forbidden, and regulations exist with reference to sanitation in drying and packing. A well-known objection to Greek currants has been removed by forbidding their being dried on surfaces coated with bovine or other excrement. Packing of currants on untiled or uncemented floors, or by tramping the fruit into containers with the feet is forbidden. Workmen must execute their

duties in sanitary uniforms and must have a doctor's certificate which is viséed every three months. Cleaning machines are to be cleansed only with salt water.

Other measures relate to methods of packing, transportation, inspection, etc. Mixing of different grades is prohibited under severe penalty.[18] Transportation in loose bulk in ships is forbidden. Residue from the cleaning machines must be delivered to the Central Currant Office (in return for retention bills), private sale of such residue being forbidden. Detailed regulations govern the methods of packing and the weight and quality of currants for export. An elaborate system of inspection extends to the vineyards, to the drying and packing plants, and even to the customs service as a final safeguard for the quality of the exports.

For Greece these regulations are of vital significance. The bad reputation which her currants had in the past, owing to unsanitary conditions,[19] was a special handicap and burden to Greek currants because the currants and raisins of competing countries were not thus encumbered. Following complaints from the United Kingdom in 1930 that the currants were not well dried, nor carefully washed and packed, the Greek government, the Central Currant Office, and the Chamber of Commerce, undertook to secure more rigid enforcement of the above regulations by issuing instructions and circulars and by sending out vigilance experts and committees to insure enforcement. The adoption of a governmental trade-mark, to be applied to all exports, with strict controls for quality, has been recently considered.

In addition to regulations designed to safeguard the quality of the exported currants, since March 24, 1920, the government has been empowered to enforce measures to prevent the spread of plant diseases and pests, chiefly phylloxera, at the grower's expense and, if necessary, without his consent.

Technical and Trade Promotional Activities.—Quite apart from the measures described above, however, the Central Currant Office has taken the initiative in many other ways which have proved helpful to the growers. In the matter of technique, for example, marked improvements have been introduced. New methods of drying on special paper or trays

[18] The currants from the islands of Zante and Cephalonia command a premium. In order to protect them from adulteration with lower grades, two decrees have been issued for preventing fraud. Mixed currants are immediately confiscated.

[19] "The conditions in the packing houses in respect to sanitation are in most cases far from satisfactory. . . . For many years all exporters shipping to the United States had to obtain "clean" Consular invoices from the United States Consular representa tives. . . . The houses packing for the United States of America are inspected and approved by representatives of the United States Public Health Service." Wheeler, L. A. International trade in dried fruits. U. S. Dept. of Commerce, Bur. Foreign and Dom. Com. Trade Promotion Series No. 44:18. 1927.

with wooden or wire bottoms have been provided to the growers through the credit system of the Central Currant Office. The trellis system is being standardized; the use of fungicides has been made more scientific; experiment stations and agricultural schools have been established. In these, and in other ways as well, the enterprise of the Central Currant Office has asserted itself to the benefit of the industry.

The more important of its activities, however, have been on the side of price maintenance. Besides stabilizing the market by the retention system, efforts have been made to stimulate demand for the product both at home and abroad—primarily for the fresh currant grapes and dried currants, secondarily for wines made therefrom, and finally, for the industrial alcohol into which unused residue may have been converted. Efforts to improve the quality and reputation of the Greek currants, with the government lending its support as indicated above, are a phase of this program. Campaigns to increase demand have been made in Germany, Japan, and the South American countries, especially Argentina. An agency of the Central Currant Office has been established in Shanghai and a sales depot in Milan, Italy. At various expositions in northern European countries, samples of Greek currants have also been shown.

Nor has the Central Currant Office neglected its leading market, the United Kingdom. It has established a branch office in London and through this office has been able to carry on at close quarters an advertising campaign in behalf of the Greek currant trade, having enlisted in its support organizations such as the Anglo-Greek Union. This campaign has been actively under way since September, 1926, and has called for no little ingenuity on the part of its sponsors. It has had to take account of notable changes in consumers' habits as compared with pre-war times, such as the increased tendency on the part of housewives to buy prepared foodstuffs rather than to do their own cooking. Hence marketing efforts have stressed encouragement of the demand for commercial bread and pastries containing currants rather than increased direct use of currants in the household.[20]

There are about 33,000 bakers in the United Kingdom, and they constitute a powerful factor in extending the demand. The Central Currant Office has accordingly formed a technical advisory baker committee consisting of English master bakers who, in collaboration with the advertising experts of the Central Currant Office, organize annual competitions

[20] Mr. Marrone, U. S. Trade Commissioner at Rome, reported on June 8, 1928, that 90 per cent of the bakeries in Liverpool sell bread containing Greek currants and that the President of the National Union of English Bakers had recommended that consumers should use currants because they were sun-dried and not processed chemically.

in various currant foodstuffs. These efforts do not strive so much towards quick results as they do towards a more enduring and permanent level of consumption. Nevertheless, other lines of effort have not been neglected. Publicity has been directed to consumers through the press and through posters and films. Some 30,000 retailers are given annually, for distributing to consumers, advertising material such as recipe books, of which over 2,000,000 have been issued. Since this advertising refers to currants generally and not to Greek currants alone, the Australian currant industry has likewise been in a position to benefit by it.

If the success of the foregoing efforts to stimulate the British demand for Greek currants were to be judged by increased volume of British imports, they would have to be regarded as futile thus far. But that is hardly a fair criterion. Under actual conditions of rapidly increasing competition brought about by the development of the seedless-raisin industry in other countries, the Greek currant industry has been placed in a defensive position in which, but for the efforts of the Central Currant Office, its sales in the United Kingdom might have been much smaller than they have been. In addition to the normal handicap which the advent of such competition would impose, the Greek industry has been confronted with the special handicap resulting from British efforts to favor Empire trade. Not only do South African and Australian industries obtain the benefit of tariff preference in the British market, but they also tend to benefit by the activities of the Empire Marketing Board (see pages 122 to 123) which endeavors to stimulate the purchase of Empire goods by a species of propaganda ("Empire consciousness") which lies outside the range of Greek sales efforts. Moreover, it must be realized that Greece's rivals, both within and outside of the Empire, are striving by similar or by other methods to promote their sales. The advertising of Australian dried fruits by the Director of the Australian Trade Publicity is having a marked effect in the retail trade. Turkey is endeavoring to improve drying and marketing conditions for sultana raisins. Under such conditions the Central Currant Office has indeed been confronted with a difficult task merely by way of striving to maintain for Greek currants something like their former position in the British market.

Efforts to Stabilize Prices Through International Coöperation.—In addition to its direct efforts to strengthen the competitive position of the Greek industry in world markets, the Central Currant Office has striven to bring about world price stabilization and the elimination of price-cutting through the medium of international coöperation.

California growers have repeatedly been accused of disorganizing the raisin and currant market by dumping raisins abroad at low prices. In

1929 the management of the Central Currant Office sent its director, Mr. Simonides, to California to negotiate with the Sun-Maid Raisin Growers Association with a view to seeking an arrangement whereby price-cutting competition would be suppressed. These endeavors did not result in any agreement, because, according to Mr. Simonides, the California growers were not sufficiently organized among themselves and they presented such diverse points of view that discussions could not be carried on with the different groups as representing the whole of the California raisin industry. He predicted, however, that within a year or two California growers would be organized and stated that they would then be disposed to enter into an agreement with the Central Currant Office. With the subsequent formation of the California Raisin Pool the first part of his forecast was borne out. However, the Pool made no attempt to work out any agreement with the Central Currant Office on the suppression of price-cutting.

Promotion of Exports of Fresh Currant Grapes and Wine.—In recent years special efforts have been directed to increasing the total market outlet for fresh currant grapes by encouraging the export of the fresh fruit (undried currants) and of wine made therefrom. In 1929–30 the Greek government and the Central Currant Office made trial shipments of fresh currant grapes to Jugoslavia, Czechoslovakia, and France, which are said to have created a very favorable impression. The Central Currant Office has been coöperating with the Association of Greek Manufacturers regarding the adoption of the most suitable containers for shipments of the fruit in the fresh form. It is generally believed in Greece that exports of fresh currant grapes will eventually exceed 65,000 tons. Assuming the total production of the currant-grape industry to remain as it is, this would mean the removal from the markets of more than 20,000 tons of dried currants, or about $\frac{1}{7}$ of the total currant output. Efforts to promote this phase of the currant-grape industry along with the table-grape industry, have been facilitated by a decree enacted as early as August 10, 1925, creating an autonomous organization for the promotion and improvement of the grape industry. Growers of the larger varieties of currant grapes (varieties which, because of their size, are preferred for consumption in the fresh state) share with growers of table grapes the benefit of this special organization.

Another outlet for fresh (as well as for dried) currants is in the making of wine. A large portion of the currant grapes has been absorbed during recent years in wine-making for foreign and home consumption; and as the Central Currant Office can accept fresh as well as dried currants, a part of its activities has been to aid in the market disposal of

such wine. To that end it acts in close coöperation with the "Board for the Protection of Wine Production and the Regulation of Wine Trade," a special board created by a decree on January 12, 1927. For a time this organization met with marked success in finding foreign outlets for this wine, especially in the French market where wine from Greek currants was used for mixing purposes. On the average, about 38,000 tons of wines made from fresh currants were shipped annually into France to be used there mainly for mixing purposes in wine-manufacturing. This quantity represented an annual average of about 16,000 tons of dried currants. In January, 1930, however, a law was passed in France prohibiting the admixture of domestic wines with imported wines, which eliminated the French market as an outlet for the Greek product. This was a real blow, and, of course, led to protests by the Greek government, thus far, apparently, without result. The Greek exports of wine to France had amounted to about 38 per cent of her total wine exports, and the international wine market was such that these exports could not easily be diverted to other countries. Italy and Germany were the next two important customers, using Greek wines mainly for mixing with their domestic product; but they could not be expected to absorb the surplus made available by the French restrictions.

Criticisms of the Central Currant Office.—As might be expected, many objections and criticisms have been made of the activities of the Central Currant Office. One of the most persistent of such objections is that it participates in the profits and losses of the wine-manufacturing industry. The objections along this line have been particularly bitter since the establishment of the French embargo against Greek currant wine. The losses entailed by the Greek currant industry, as a result of that embargo, will of course reduce the financial power of the Central Currant Office in backing the dried-currant producer. It should be borne in mind, however, that as far as the French embargo is concerned the Central Currant Office is simply a victim of circumstances brought about by factors over which it has no control. It has also been severely criticized because of the levies and special taxes that have been imposed from time to time on currant growers and exporters.

The main objection raised against the Central Currant Office in Greece is based on the operation of its price-maintenance policy. It is claimed that the enforcement of large retention quotas has raised prices to such high artificial levels that export sales have been seriously curtailed and the competition of foreign producers proportionately stimulated, the contention being that more elasticity of retention quotas would have permitted greater exports. No attempt will be made in this

report to analyze the relevancy or consistency of these local objections. From the purely disinterested point of view of agricultural economics, however, one might point out that the activities of the Central Currant Office come into conflict with certain broad principles of land utilization and freedom of action, and as a result, those immediately involved might justly be entitled to further consideration. One authority[21] has pointed out that, considered on this basis, objection might be made against the principles involved in the policy of the Central Currant Office by the following groups: (1) the Greek population as a whole, whose national income may suffer as a result of land not being used in the most efficient and economic manner; (2) the growers of wine grapes, who have suffered from the dumping of currants into the wine industry; and (3) those growers of currants who would have survived without government intervention in the industry and who, as a result, are now compelled to carry the burden of uneconomic production by others.

Apart from any possible disturbances in distribution, the Greek currant valorization scheme has undoubtedly been a barrier to the improvement and diversification of agriculture as a whole. Moreover, it is obviously disadvantageous for the Greek currant industry to be compelled to carry the dead weight of submarginal producers, who are now able to dump their low-grade produce into the warehouse of the Central Currant Office when they would have been eliminated under conditions of free competition. The low-grade currant is more affected at present by the sultana-raisin competition than the high-grade currant. The more that sultanas replace currants in the markets of the world the heavier will be this deadweight of submarginal producers, and the sooner the Central Currant Office will have to change its policy in regard to inducing the grower to improve the quality of his output.

The main objection against the rationalization and stabilization methods now employed by the Central Currant Office seems to be that it is trying to bring about an improvement of quality by legislative measures rather than by exposing the low grade and submarginal grower to competition which would eventually force him to improve his product or to cease production. The Central Currant Office will not be able to make currant growing a profitable business in Greece until the submarginal and low-grade producer is forced out.

[21] Kipps, J. The Greek currant trade. Econ. Hist. (supplement of the Economic Journal) 2(5):152. 1930.

THE GREEK RAISIN INDUSTRY

Most of the Greek raisin output (as distinguished from currants) consists of sultana raisins, produced in the Candia district of Crete and also on the Greek mainland, particularly in the Peloponnesus. The rosakia, made from a light-colored seeded grape similar to the Turkish Rosakia, is also produced to a limited and decreasing extent. This variety is little grown in California and is known here as Dattier de Beirut.

TABLE 16

GREEK* PRODUCTION AND EXPORTS OF RAISINS, FOR CROP YEARS, AVERAGE 1909–1913, ANNUAL 1920–1933

Year harvested	Production	Exports†	Year harvested	Production	Exports†
	short tons	*short tons*		*short tons*	*short tons*
Average:			Annual (*continued*)		
1909-1913	18,000	12,508‡	1926	20,000	14,180
Annual:			1927	22,300	16,304
1920	13,000	8,789	1928	22,500	16,651
1921	22,000	16,195	1929	22,000	15,433
1922	21,000	15,085	1930	21,500	14,315
1923	18,000	12,604	1931	21,500	14,334
1924	22,500	16,761	1932	27,000	19,800§
1925	21,500	15,712	1933	29,000§	—

* Including Crete.

† Exports are for years beginning August 1.

‡ Average for Greece proper for the calendar years 1907–1911 plus an average for Crete for the calendar years 1908–1912.

§ Preliminary estimate subject to revision.

Sources of data:

Average production 1909–1913 is an estimate by S. W. Shear based upon the export data given and is believed to be fairly comparable with Nielsen's post-war estimates. Average exports 1909–1913 are from official data for Greece and Crete, which was not under Greek rule until 1912. Years 1920–1933 estimates of U. S. Agricultural Commissioner N. I. Nielsen, Marseilles, France. For currant data see: Federal-State Market News Service, Foreign Raisin Reports. (Mimeo.) Sacramento, California.

PRODUCTION[22] TREND

The most accurate indication of the growth of the commercial raisin industry of Greece (including Crete[23]) is exports, which averaged about 12,500 tons in pre-war years and from 14,000 to 16,000 tons in recent years (see table 16). Exports from Crete alone, for the calendar years 1908–1912, averaged 7,755 tons with normal production probably of

[22] Greek raisin statistics usually are designated as "sultanas" but apparently at times include rosakias as well as sultanas for the government sometimes calls any dried grape that is not a currant a sultana, according to J. L. Simpson in his unpublished report in 1923 on the "Greek Currant Situation."

[23] Crete did not come under Greek control until 1912 and so pre-war data for Greece exclude Crete unless otherwise stated.

about 8,000 or 9,000 tons, practically all of which consisted of rosakias.[24] Exports from Greece proper averaged about 5,000 tons for the years 1907–1911. Apparently about half of these were sultanas. From the meager and questionable data available[25] it appears that total production was probably not much greater than exports.

Contrary to general opinion the best data available on the output of raisins in Greece and Crete (table 16) show but little increase during the past decade.[26] However, Nielsen[27] states that it seems probable that there actually has been an increase in the production of the sultana variety in recent years, as the trade believes, particularly in Crete where extensive plantings by Greek refugees from Turkey are said to have been made since the World War. The output of sultana raisins has apparently

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[24] The British consul reported that the production of sultana raisins in Crete in 1911 was estimated at only about 125 long tons, but that this variety had proved profitable and its production and exports were on the increase. Export data and production estimates are from: Statistique du Rendement Agricole des Nouvelles Provinces 1914 (production for 1914 reported as 15,200,055 pounds), and from the Annual Series of British Diplomatic and Consular Reports on Trade, Shipping, and Agriculture of Crete. (No. 4982:7, 1911; No. 4238:22, 1907; No. 4776:13, 1910; and No. 5393:7, 13. 1914.)

[25] Annual Series of British Diplomatic and Consular Reports on Trade of Consular Districts of Patras, Greece, No. 5297:10, 1913; No. 4870:10, 1911; No. 5065:12, 1913; and No. 4649:9, 1910. These Consular Reports indicate normal production of the sultana variety to have been about 3,000 tons, but give no data on other varieties.

Recensement Agricole de la Grece (1911) reports approximately 7,500 acres of grapes designated as Sultanas but probably including all other raisin grapes, with a production of 58,355 quintals and a value of 4,372,101 francs. From the secondary sources at hand it is impossible to tell whether the quintal used is the Greek quintal of 123.4576 pounds or the metric quintal of 220.46 pounds avoirdupois. The smaller conversion factor would indicate production of about 7.2 million pounds, the larger factor about 12.8 million pounds. The Austria-Hungary Consular Report (on Griechland Wirtschaftliche Verhältnisse, 1913, p. 24) states that raisin production in the Peloponnesus for 1913 was 5,958,699 Venetian pounds or approximately 6.3 million pounds avoirdupois and also that the 1912 crop was about the same size. E. J. Tsouderos (in Le Relèvement Économique de la Grece, 1919, p. 135) states that the total production of raisins (probably all raisins although designated as sultanas) in all Greece, including Crete, in 1914 was 10,145,000 okes, or approximately 28.6 million pounds avoirdupois, with a value of 3,257,267 drachmas. The new provinces, the chief raisin-producing area of which was in Crete, are officially reported as producing 5,841,260 okes or approximately 16.5 million pounds. By subtraction the production of old Greece, excluding Crete, apparently was estimated at about 14.1 million pounds in 1914. Unfortunately the official Greek acreage and production estimates seem to be of somewhat questionable accuracy.

[26] The production data in table 16 show the same absence of trend since they are estimates based upon exports with an allowance of approximately 6,000 tons for home consumption. These estimates agree rather closely with trade estimates of recent years.

[27] Nielsen, N. I. United States Agricultural Commissioner, Marseilles, France, letter of July 28, 1932. Since this manuscript was submitted for publication the Marseilles office has been discontinued and the Agricultural Commissioner is now located at the American Embassy in Paris, France.

[Great Britain] Imperial Economic Committee. Report on the marketing and preparing for market of foodstuffs produced in the overseas parts of the Empire. Third Report—Fruit, p. 171. 1926.

increased at a much faster rate than total raisin production as a result of Sultana vines replacing many Rosakias. He estimates that Sultanas now constitute more than 75 per cent of the total raisin output of Greece and Crete.

EXPORT MARKETS

Total exports of all types of raisins from Greece during the crop years 1926–1930 averaged 31,275,000 pounds annually (see table 17), going mostly to Italy, Germany, and the United Kingdom. It should be borne

TABLE 17

EXPORTS OF SULTANA AND ROSAKIA RAISINS FROM GREECE BY COUNTRIES OF DESTINATION, AVERAGE 1920–1924, ANNUAL 1925–1931

(Years beginning September 1)

Destination	Average 1920–1924	1925	1926	1927	1928	1929*	1930*	1931*
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom	8,670	7,475	7,172	6,166	7,970	7,886	6,602	7,846
Italy	5,228	12,439	11,314	12,200	12,791	10,552	11,926	11,040
Germany	3,836	5,178	6,933	7,727	8,741	8,160	7,500	7,772
United States	1,325	143	106	157	172	16	—	—
Netherlands	2,976	2,169	1,814	3,999	2,467	1,846	1,218	1,122
Egypt	1,745	2,302	481	377	778	176	28	138
France	1,100	508	179	807	600	52	200	174
Jugoslavia	307	—†	—	—	—	138	176	288
Norway	787	25	—	—	—	—	—	—
Turkey	146	—	—	—	—	—	—	—
Belgium	79	405	251	778	454	—	—	—
Other countries	1,664	336	1,283	785	375	2,040	980	288
Total	27,863	30,980	29,533	32,996	34,348	30,866	28,630	28,668

* Crop year beginning August 1.

† Dashes indicate data not available for individual countries. Any exports to these countries are included in "other countries."

Sources of data:

1920–1928: from Bulletin Mensuel du Commerce Special de la Grece, August and December.

1929–1931: from U. S. Agricultural Commissioner, N. I. Nielsen, Marseilles, France. (See: Federal-State Market News Service, Foreign Raisin Report No. **39**: 14. March, 1933. [Mimeo.] Sacramento, California.)

in mind that much of the trade with Italy consists of transit goods going to central Europe, especially to Germany, via Trieste. Obviously then Germany is the most important export outlet for Greek raisins. As the Greek sultana raisin is similar in its characteristics to the Turkish sultana it shares the decided preference that is given by German consumers to the latter over bleached California sultanas, even though the prices of California sultanas may be slightly lower. The increasing German demand for sultanas generally, and for unbleached sultanas in particular, seems to favor the Greek raisin industry.

GOVERNMENT ASSISTANCE

The Greek raisin industry has not been the recipient of special legislative aid, although a number of minor enactments have presumably been helpful to the industry, such as laws advancing credit to farmers, regulations concerning drying methods, and the establishment of a board for the promotion of exports of fresh grapes.

THE SMYRNA RAISIN INDUSTRY[28, 29]

Fresh grapes are grown throughout both European and Asiatic Turkey from which raisins are produced for local consumption in several regions. However, no data are available concerning the production of raisins in these noncommercial areas. The commercial production of raisins for export is confined almost exclusively to the Smyrna (Izmir) region on a strip of land in the coastal districts about 75 miles long and about 75 miles wide at its maximum. Fairly accurate data on production and export of raisins from this district are available from trade sources for a good many years.

Three principal kinds of raisins are produced in the Smyrna raisin belt: sultanas (the Thompson Seedless of California); rosakias (Eleme, the seeded white Dattier de Beirut in California); and the Turkish Black. The last two varieties are now used mainly for wine-making or for consumption in the fresh state. At present, about 98 per cent of the total Smyrna raisin output is sultanas,[30] which constitute practically all of the export movement.[31]

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[28] Shortly before his death in December, 1932, the manuscript of this chapter was reviewed by R. L. Nougaret, Viticulturist in the Turkish Institute of Viticulture and formerly Viticulturist in the California State Department of Agriculture. The few changes he suggested in the manuscript have been incorporated in the chapter as it now stands.

[29] General sources used for this section in addition to those given in specific footnotes:

Giraud, D. J., and Co. Smyrna, Turkey. Smyrna raisins and figs. 24 p. Smyrna. 1924.

Rizzo. La legislation Turque; lois promulguees etc., Editions Rizzo, Constantinople. (This collection represents a French translation of Turkish legislation. A survey of legislative documents in Turkish language was made in Washington, D. C.)

[30] Courdoglou states that only 10 per cent of the total fresh sultana output is consumed fresh, while 90 per cent is dried. Courdoglou, Faik. La Turquie economique. p. 81. Librairie de l'Institut, Anvers. 1928.

[31] For a discussion of the kind of raisin grapes produced in the different producing areas of Smyrna see Nougaret, R. L. The Smyrna raisin industry. California Grower 5(3):12–13. March, 1933.

PRODUCTION TREND

Raisins have been grown in Smyrna for many years. Eisen[32] pointed out in 1890 that the production of Smyrna raisins and dried grapes had increased enormously during the preceding years (see table 18). He also stated that if Smyrna raisin production that year was as high as esti-

TABLE 18

Raisin Production* of Smyrna District, Specified Years, 1844–1884, Annual 1903–1933

Year harvested	Production	Year harvested	Production	Year harvested	Production
	tons†		*tons*†		*tons*†
1844	6,000 to 8,000	1908	62,800	1921	37,400
1868	19,000	1909	60,200	1922	41,200
1871	48,000	1910	49,100‡	1923	40,400
1872	31,000	1911	24,500	1924	54,300
1879	75,000	1912	60,200	1925	33,100
1881	49,000	1913	68,900	1926	39,100
1884	95,000	1914	57,100	1927	52,900
		1915	50,700	1928	50,200
1903	76,200	1916	38,100	1929	56,200
1904	39,700	1917	31,700	1930	41,500
1905	60,300	1918	28,500	1931	31,000
1906	30,400	1919	33,600	1932	70,000
1907	47,600	1920	20,300	1933§	62,500

* Because of conflicting data from different sources or different designations for the same data, one cannot be sure whether data for years 1903–1922 represent exports or total production, and, if exports, what kind of a year is given—calendar year or crop year. The source is quoted as the Smyrna Chamber of Commerce and the data designated as *raisin exports* with kind of year not stated in: Bey, D. S. The Smyrna fig and raisin industry. Levant Trade Review **16** (1): 17–21. January, 1928. The same data are quoted as from the Smyrna Chamber of Commerce in: Annuaire de Statistique Vol. 1, 1928 (Official Government Statistics of Turkey), and by U. S. Trade Commissioner Gillespie in 1925 as *raisin production.*

† Kind of tons not specified by Eisen for years 1844–1884 but probably short tons. Data for 1903 to date in short tons.

‡ The author has been unable to reconcile conflicting data on Smyrna raisin production for 1910 from different sources. Data from other sources which appear fairly reliable indicate production to have been unprecedently small in 1910, amounting to about 20,000 to 21,000 tons only. See data (21,200 short tons) quoted by Jacob Caramin and Fils of Smyrna. Levant Trade Review **4** (1): 109. June, 1914. Also see data (17,600 short tons) quoted by British Consul at Smyrna in Board of Trade Journal **76**: 378. February 15, 1912.

§ Preliminary estimate, subject to revision.

Sources of data:
1844–1884: from data compiled from consular reports by: Eisen, Gustav. The raisin industry. H. S. Crocker and Company, San Francisco. 1890.
1903–1925: furnished by Smyrna Chamber of Commerce in Annuaire Statistique, 1928. Vol. 1.
1926–1929: reported by U. S. Consuls.
1930–1933: from U. S. Agricultural Commissioner, N. I. Nielsen, Marseilles, France.

mated, i.e., 100,000 tons, it would be absurd to think that only one-tenth were of the sultana variety, which was known to be one of the most important raisins of the district. In his opinion not less than one-third of the whole raisin crop in 1890 consisted of sultanas. This seems to imply that a shift had been taking place in the varieties of raisins grown and that at that time there was a decided trend toward the producing of sul-

[32] Eisen, Gustav. The raisin industry. H. S. Crocker and Co., San Francisco, 1890.

tanas. The fact that growers as early as 1890 were devoting increased attention to seedless types indicates the trend in consumer preference near the end of the last century.

Table 19 shows the marked upward trend in the commercial output of Smyrna sultana raisins from 1900 to 1910. Exports of sultanas from Smyrna during the five years, 1900–1904, averaged 34,700 tons, or approximately 70 per cent of the total movement of raisins from that port.

TABLE 19

EXPORTS OF RAISINS BY KINDS FROM PORT OF SMYRNA, 1900–1904 AND 1906–1910

Year*	Total, all varieties	Sultana (in sacks and cases)	Black (in bags)	Rosakias (in small bags)	Beylerdje (in sacks)
	short tons†	*short tons*†	*short tons*†	*short tons*†	*short tons*†
Averages:					
1900-1904	49,400	34,700	8,600	4,800	1,300
1906-1910	50,400	43,500	4,800	1,700	400
Annual:					
1900	33,000	18,100	8,200	5,100	1,600
1901	44,000	27,100	8,200	7,300	1,400
1902	47,600	34,800	7,600	3,800	1,400
1903	67,400	52,600	8,700	4,600	1,500
1904	54,700	41,000	10,100	3,200	400
1906	50,800	39,700	7,100	2,600	1,400
1907	46,700	41,500	3,600	1,500	100
1908	51,200	45,300	3,500	2,300	100
1909	63,000	58,100	3,300	1,500	100
1910	40,300	32,800	6,700	700	100

* Kind of year not indicated in Consular Reports from which data are drawn.

† Kind of tons not indicated in Consular Reports from which drawn; hence data were converted to nearest hundred short tons on supposition that metric tons were shown in Consular Reports.

Source of data:
Compiled from British Consular Reports of 1904, 1905, 1908, and 1910–11 on the Trade of the Consular District of Smyrna, Turkey.

In the five years, 1906–1910, however, sultana exports had increased to 43,500 tons and constituted 86 per cent of the total of raisin exports from Smyrna.

The value of table 18 lies in the fact that it throws some light upon the potentialities of the Smyrna region, under improved cultivation, as a competitor for the world's raisin market. If, under less scientific cultivation methods and other handicaps, almost 100,000 tons of raisins were produced in Smyrna around 1890, it is safe to say that the former quantities could be produced again, especially since there is no sign of soil exhaustion even though growers do not use artificial fertilizers.[33]

[33] R. L. Nougaret's comment on this sentence was "true." British consular reports for the Smyrna district also concur in the fact that there is much land adapted to raisin expansion in the Smyrna district. See also page 43.

Acreage.—The production figures in table 18 do not indicate the changes that have taken place in the raisin-grape acreage of Smyrna. Courdoglou,[34] a Turkish author, places the total area under vines for 1924 in what he calls the "economic region of Smyrna" at about 328,680 acres, of which 96,580 acres were in the province of Smyrna and 52,300 acres in that of Magnesia. The acreage in these two provinces, at least, is assumed to be entirely Sultanas. He adds that the areas devoted to raisins in the entire Smyrna economic region increased by at least 25 per cent between 1924 and 1928. This would place the Sultana area of the province of Smyrna in 1928 at 121,000 acres and that of Magnesia at 64,000 acres. In addition, increases probably took place in the other provinces[35] as well. A statement early in 1931 by a second authority[36] indicates that in spite of the unsatisfactory economic situation, the acreage devoted to the cultivation of vineyards in the Smyrna region is increasing yearly and under normal circumstances the yield is expected to increase correspondingly every year. The Smyrna Chamber of Commerce estimates that there were about 126,000 acres in vineyards in the Smyrna district in 1930, which is about 5,000 acres more than that given by Courdoglou in 1928.

Spells of unfavorable weather, which occurred rather often during the drying and growing season in several recent years, may partially account for the fact that this increase in acreage does not show up in the production figures. It must also be borne in mind that a great many acres of new plantings have not yet come into bearing. Lower yields per unit may also have resulted from other factors. From 1911 to 1922, for example, Turkey was at war continually. The resulting losses in man power are still influential in the raisin situation. In the case of raisin growing a man cannot be replaced by machinery. Many vineyards, therefore, did not receive the attention necessary to guarantee high yields. The productivity of many old plantings undoubtedly suffered from continuous neglect or devastation during the Greek invasion (1919–1922), which turned the entire Smyrna raisin region into a battlefield. It is also quite possible that the subsequent expulsion of the highly qualified class of growers who happened to be of Greek nationality, was detrimental to raisin production.

The Turkish government after the Greek invasion placed about 20,000 acres of raisin land under the administration of the "Abandoned Property Commission" to be settled by the government with repatriated

[34] Courdoglou, Faik. La Turquie economique, p. 82. Librairie de l'Institut, Anvers, 1928.

[35] Aiden, Mughla, Balikesri, Denizli, Burdur, and Sparta.

[36] Report from United States Consulate, Smyrna, dated January 5, 1931.

Turks. Many of the repatriated Turks, who have to date taken the place of the expelled Greeks under this arrangement, were not thoroughly familiar with viticulture, except those coming from Crete.[37] Most of them are said to have taken more to tobacco growing since they came mainly from tobacco-producing areas in western Thrace. In the Kara-Burun peninsula head at the entrance to the Gulf of Smyrna, which produces the finest type of sultana raisin grown in Smyrna, 35 per cent of the raisin acreage is said to have been dedicated to other crops, mainly to tobacco.[38] Some acreage losses of this kind undoubtedly have been offset by increased plantings elsewhere.

An additional factor accounting for the low yields per unit obtained in the Smyrna raisin industry may be found in the general disinclination of the growers to adopt new methods of cultivation.[39] This characteristic has been accentuated by the conditions which prevailed under the old Ottoman Empire government.[40] It is believed, however, that the energetic and enterprising Kemalistic republican form of government will succeed in removing many handicaps of the raisin industry by means of social evolution and in increasing the yield per unit by the introduction of improved methods. Turkey undoubtedly could greatly expand her raisin-growing industry as far as available land is concerned. For example, the pre-war province of Aiden, to which the Smyrna region belonged, had in 1909–10 around 258,066 acres, or 17.4 per cent of its cultivated acreage under vines. Only 10.5 per cent of the total acreage of the province, however, was actually under cultivation while 25.7 per cent was still available to cultivation.[41] Even assuming

[37] The various sources on this question mention that on the whole, 800,000 to 1,000,000 Turks were repatriated from Greece. Undoubtedly there were among them a considerable number of men skilled in viticulture. These, having acquired their knowledge under somewhat more liberal conditions than prevailed in ancient Turkey, were expected to constitute an important factor for the improvement of raisin growing in Smyrna. At least they could substitute for the expelled Greeks.

[38] Ravndal, G. Bie. Turkey: Commercial and industrial handbook. U. S. Dept. Com. Bur. of Foreign and Dom. Com. Trade Promotion Series No. 28. 1926.

[39] "It is one of the anomalies of the character of the native that, though he is shrewd and calculating in all matters financial, he will sacrifice, as a rule, his own pecuniary advantage rather than break with tradition and custom." Mears, Eliot G., *et al.* Modern Turkey; a politico-economic interpretation, 1908–1923. p. 297. The Macmillan Company, New York. 1924.

[40] Bitter experience under the old régime has taught the peasant in Turkey the uselessness of producing more than is absolutely necessary for his living and for the payment of taxes, and his tendency is always to remain the same or even to retrograde. Ravndal, G. Bie. Turkey; commercial and industrial handbook. U. S. Dept. Com. Bur. of Foreign and Dom. Com. Trade Promotion Series No. 28. 1926.

[41] Mears, Eliot G., *et al.* Modern Turkey; a politico-economic interpretation, 1908–1923, p. 284. The Macmillan Company, New York. 1924. Based on "Résumé of agricultural conditions in Turkey, Asia, and Africa, 1912." Unfortunately the "Compte Rendu du Recensement Agricole de 1927" does not show any figures on the acreage under vines, for comparison.

TABLE 20

Raisin Exports from Turkey by Country of Destination, Calendar Years, Average 1909–1911, Annual 1923–1932

Destination	Average 1909–1911*	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom	39,488	43,465	33,416	11,856	26,242	7,353	31,689	26,080	15,095	10,648	43,532
Netherlands	11,068	9,853	33,634	9,233	6,738	7,478	14,383	23,632	15,567	6,660	18,012
Germany	14,413	2,461	21,160	17,416	20,527	18,212	51,418	31,688	32,679	20,150	18,951
Italy	878	6,330	8,323	7,552	6,021	3,140	14,825	13,512	13,839	5,842	7,388
Belgium	2,990	4,450	3,799	2,770	1,912	1,397	3,097	2,950	3,542	2,740	7,416
United States	609	1,406	2,726	1,041	391	1,158	1,356	1,719	775	245	578
Egypt	2,710	1,224	954	†	603	769	1,281	1,337	1,274	567	1,001
France	8,836	641	351	†	494	655	681	854	1,340	758	1,722
Switzerland	†	†	4	0	21	‡	5	137	‡	†	†
Austria§	14,056§	†	†	0	74	248	125	63	11	†	†
Czechoslovakia	†	†	0	0	0	5	‡	9	†	†	†
Poland	†	†	†	†	0	‡	†	†	†	†	†
Other countries	6,563	2,920	2,296	2,643	977	1,283	3,706	3,285	3,732	536	1,156
Total	101,611	72,750	106,663	52,511	64,000	41,698	122,566	105,266	87,854	48,146	99,756

* Years beginning March 14.

† If any, included with "other countries."

‡ Less than 500 pounds.

§ Austria-Hungary in pre-war years.

Sources of data:

1909–1911: from Statistique du Commerce Exterieur de L'Empire Ottoman.

1923–1926: from Die Wirtschaft des Auslandes. p. 644. Berlin, 1928 [quoting from original Turkish sources "Lenesinine Mahsus Ticareti Hariciye Istatistiki" 1339 (1924), 1340 (1925 and 1926).]

1927–1928: from Annual Statistics, Turkish Customs.

1929: from monthly statistics of Turkish customs.

1930: preliminary data from Consular report of January 5, 1931, quoting figures furnished by Smyrna Chamber of Commerce.

1931–1932: from report of American consul, W. Perry George, January 12, 1933, for Smyrna (Izmir) district only.

that only a part of the uncultivated land in that region should be used for vines, the vineyard area could probably be increased considerably. Another region for expansion is found in the Province of Trapizond, where conditions are favorable and where sea transportation is easily obtained through the port of Trapizond and the Black Sea. The government, however, seems to be more interested in developing nut and citrus-fruit cultivation in the latter area.

TABLE 21

IMPORTS FROM TURKEY BY THE PRINCIPAL IMPORTING COUNTRIES, CALENDAR YEARS, AVERAGE 1909–1913, ANNUAL 1923–1931

Importing country	Average 1909–13	1923	1924	1925	1926	1927	1928	1929	1930	1931
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom	41,537	46,053	29,905	12,502	31,035	24,239	19,393	25,254	15,805	11,878
Netherlands	9,354	6,931	10,966	4,389	3,652	7,289	7,658	12,811	13,773	5,317
Germany	33,761	5,536	37,845	32,665	32,678	33,646	36,828	39,388	41,577	30,143
Italy	1,380	50	195	1,414	421	1,638	2,159	—*	—	—
Belgium	2,994	1,437	3,402	5,315	2,106	2,474	3,236	3,588	2,431	1,532
United States	1,445	1,534	1,914	1,278	394	626	484	621	736	395
Egypt	—	441	1,034	916	816	1,011	1,009	1,281	1,407	741
France	7,025	1,136	1,418	1,394	511	766	713	—	1,430	1,178
Switzerland	419	331	305	225	325	678	436	418	831	791
Austria	—	152	186	231	519	1,067	—	—	3,006	2,813
Czechoslovakia	—	66	416	236	704	1,385	1,527	1,938	1,845	—
Poland	—	—	565	551	267	775	606	530	137	—
Canada	1,782	1,046	1,185	332	561	666	576	548	227	18
Total	99,697	64,713	89,336	61,477	74,094	76,322	72,475	86,402	58,355	54,806

* Dashes indicate data not available.

Source of data: Compiled from the official trade statistics of the various countries.

TREND OF EXPORTS

The available statistics on exports of raisins from Turkey indicate that shipments since the War have been below those of pre-war years. During the past five years, 1926–1930, for example, exports have averaged 84,277,000 pounds annually as compared with an average of 101,611,000 pounds annually during the three years 1909 to 1911 (table 20). Before the War the United Kingdom was the main export outlet. Since the War, however, Germany has replaced the United Kingdom as the most important purchaser. However, Germany buys mostly lower-grade raisins. In fact, Continental Europe now takes the bulk of the Turkish raisin exports.

When the statistics on raisin exports from Turkey are compared with those of the various countries concerned giving imports for consumption, several interesting facts are brought to light (table 21). The first

is that the Turkish export statistics by countries of destination do not give an accurate picture of the relative importance of the different raisin export markets. Official German statistics show average annual imports of raisins for the years 1926–1930 about 6,000,000 pounds greater than Turkish statistics report as exported directly to Germany (30,905,000 pounds as compared with 36,823,000). The bulk of the raisins indicated in the Turkish statistics as being exported to Italy in reality represent a transit trade via Trieste and Genoa for other European markets, especially to Germany. The Netherlands, like Italy, also figures as an important base for such transit trade. A further glance at the Turkish export statistics would seem to indicate that such markets as Poland and Czechoslovakia are of practically no importance as export outlets, but a glance at the import statistics of those countries immediately reveals that they take in the aggregate around 2,000,000 pounds of raisins from Turkey.

There has been some objection against Turkish raisins in Great Britain in recent years on the grounds that they were not being processed under sanitary conditions.[42] This fact, together with the increasing competition from California and from British Empire raisins (the latter imported under preferential rates of duty) as well as from somewhat improved sultanas[43] and currants from Greece, has caused the decline in Smyrna sales on the British market. This decline, however, has been offset by increased sales to the Continent, where British Empire raisins have no preference and where the Greek currant is not so much appreciated, probably because of its characteristics and high price. Moreover, Germany has granted a preferential duty rate to Turkish raisins, which has materially increased sales in that market.

The Smyrna sultana is said to be one of the best raisins of its kind entering into international trade. This is partly due to the fact that it

[42] "On account of the unsanitary conditions prevailing in the raisin-packing industry of Smyrna, a system of inspection was established several years ago by the American Consulate at Smyrna for the purpose of insuring, so far as possible, sanitary treatment of raisins intended for exports to the United States. Before being put on the list of exporters qualified to ship to the United States, the packer has to satisfy an inspecting physician appointed by the Consul General at Smyrna as to the health and cleanliness of his employees and the sanitary conditions of his plant. If the conditions are fulfilled a 'clean' invoice is issued by the Consulate." This particular inspection is still carried on at present. (Wheeler, L. A. International trade in dried fruits. U. S. Dept. Com. Bur. of Foreign and Dom. Com. Trade Promotion Series No. 44. 1927.)

[43] The growing of Sultanas, especially in Crete, has been developed with very good results by the Greek farmers expelled from Smyrna and repatriated in Greece. "The British dealers seem to display a certain favorable attitude toward Greek produce. This may be attributed to the fact that the majority of the business men in the dried-fruit trade in British ports are Greek." (From: United States Consular Report, January 5, 1931.)

is light in color without bleaching with sulfur dioxide.[44] Its price, moreover, is usually lower than that of other raisins. Should Turkey succeed in improving processing methods so as to be able to place on the world market an attractively packed product, it may happen that the Smyrna sultana will become a much more serious competitor than at present.

GOVERNMENT ASSISTANCE

Pre-War Situation of Turkish Agriculture.—Before the World War, Turkish agriculture labored under the handicap of a corrupt and most inefficient government, with lack of security of person or property. Land tenure and mortgage laws, the taxation and credit system, lack of education, and primitive cultural, marketing and transportation methods were all serious obstacles to the progress of the raisin industry. Moreover, agriculture was injured by the War, particularly in the Smyrna raisin-producing area, by the Greek occupation from 1919 to 1922.

Constructive Republican Agricultural Policy Since 1923.—According to American standards, present agricultural and general political and economic conditions in Turkey leave room for much improvement. However, since 1923 the new Turkish republican government, as a result of a constructive policy towards agriculture, has advanced the industry considerably. The abolition of the old system of farming out the collection of taxes, formerly the main obstacle to agricultural progress, was one of the first acts of the new government. Tax rates were also reduced from 12½ per cent of the produce to 8 per cent of the peasant-farmer's income. Various educational measures have also been adopted which are improving agricultural conditions—slowly, to be sure, for extension of agricultural knowledge is very difficult since only a few peasants know how to read or write.

Legislative provisions for establishing credit coöperatives have resulted in the establishment of numerous local agricultural organizations of this kind that also engage in coöperative selling and buying. A vineyardist's bank established in 1926 in Magnesia, one of the important raisin-producing provinces, not only extends credit to members, but also sells raisins to Smyrna exporters. Permission to cut wood for farm use in the state forests of one province has been of considerable help to raisin growers in providing material for buildings, posts, and the manufacture of raisin boxes. Free distribution of phylloxera-resistant vine stocks for planting has been provided since December, 1925, and state

[44] Nougaret, R. L., writes (November, 1932) that Smyrna raisins acquire their light color and characteristic texture and flavor by dipping in potash solution and an olive-oil emulsion in the bleaching process. No sulfur dioxide is used by the grower although occasionally the exporter may use it.

land has been made available to provincial and municipal governments for the establishment of nurseries. Importation free of duty of materials needed in the raisin industry has also been arranged for in recent years.

Beginning of Improved Transportation.—Improved transportation by motor trucks is also being encouraged in inland provinces by building roads, by the opening of government motor-repair shops, and by the exemption of gasoline for agricultural purposes from import duties and consumption taxes. However, Nougaret[45] states that aside from the very few highways that serve as main arteries of communication, the country roads of Turkey are so narrow and poor that raisins are still largely transported from vineyards to Smyrna on the backs of donkeys and camels. This mode of conveyance accounts for the use of burlap sacks of about 300 pounds as the usual packing container. Measures to improve and cheapen motor transport, together with the promotional activities of the Anatolian Railway Company, should result in improved marketing and transportation facilities and may possibly bring about the opening of new raisin-producing areas.

Measures to Improve Quality of Raisins.—In order to remove the old prejudices against Turkish raisins in export markets, the government has been conducting a vigorous campaign in recent years to improve raisin-processing methods. Drying raisins on surfaces coated with manure, formerly a general practice, is forbidden, and growers are being encouraged to dry on paper. However, because of the expense involved very few have adopted this practice. Nougaret[46] states that most of the raisins are still dried on the ground on a hard smooth surface prepared from a mixture of gray clay, mud, and straw. A few of the most progressive growers have recently equipped their drying yards with tents, so constructed as to be rapidly drawn over the drying beds when necessary as a protection against rains, which unfortunately normally occur before drying is completed. These tents are too expensive for most growers. The government, however, in an effort to encourage more growers to improve the quality of their raisins by using them, has extended special credit to growers for this purpose through the Agricultural Bank of Manisa, a government institution. A commission of government officials, with the aid of a physician, enforces sanitary regulations in all packing houses, and refuses export permits unless all sanitary requirements are complied with.

The government alcohol monopoly, established in June, 1925, has

[45] Nougaret, R. L. The Smyrna raisin industry. California Grower 5(3):12–13. 1933.

[46] Nougaret, R. L. The Smyrna raisin industry. California Grower 5(3):12–13. 1933.

helped the Turkish raisin industry by purchasing all damaged and otherwise unexportable fruit; this step has tended to improve and stabilize prices.

The Smyrna Raisin Exchange, a semiofficial institution, has been operating since 1924, with its major purpose the improving of marketing conditions. Growers no longer haul their raisins from one exporter's warehouse to another in order to complete a sale. All sales must now be made on the Exchange through the sellers' brokers by means of samples stored in central warehouses. Control is exercised by registering each sale and publishing the price and other essentials of the transaction, so that growers as well as the trade may be kept well informed.

A very limited amount of advertising of Turkish raisins in European markets has been done by exporters and Turkish delegations abroad. Partially as a means of advertising, it has been necessary since 1925 to mark all containers with the name of the product, the trade-mark, the name of the exporter, and place of origin. As yet, compulsory government grades and standards have not been adopted but such action is to be expected as a means of strengthening the reputation of Smyrna raisins in foreign markets.

In general it may be said that the new republican government of Turkey has displayed much more interest in the welfare of farmers than did the old Ottoman government. While there have been no legislative measures directly concerned with the regulation of raisin production or the control of raisin prices and exports, the several general agricultural measures enacted have been instrumental in stimulating and encouraging greater interest in the industry. Undoubtedly the Smyrna raisin industry possesses great potentialities for future development. This is particularly significant in view of the fact that most of the other raisin-producing areas of the world have already adopted the latest scientific methods for both production and distribution and therefore cannot hope to make much further progress. With the general adoption of scientific methods of production, processing, and marketing, the Smyrna raisin industry might well become a much more important competitor in the world's raisin markets than it is at present.

THE CYPRUS RAISIN INDUSTRY[47]

The island of Cyprus, situated in the east corner of the Mediterranean basin, produces mainly dark, seeded raisins, but in recent years a few sultana raisins have also been produced. Since production figures are not available, the volume of the industry must be determined largely

TABLE 22

VINE ACREAGE AND RAISIN EXPORTS OF CYPRUS, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Area under vines*	Raisin exports	Calendar year	Area under vines*	Raisin exports
	acres	*1,000 pounds*		*acres*	*1,000 pounds*
Average:			Annual (*continued*)		
1911-1913	45,718	6,833†	1925	86,979	7,606
			1926	87,597	7,400
Annual:			1927	86,873	9,850
1920	50,752	4,067	1928	92,559	10,906
1921	46,702	3,966	1929	91,733	10,874
1922	54,406	4,040	1930	111,852	11,553
1923	79,759	4,226	1931	—‡	5,978
1924	88,210	10,274	1932	—	6,984

* Grapes of all kinds.

† 1909–1913.

‡ Dash indicates data not available.

Sources of data:
Compiled from Internatl. Yearbook of Agr. Statis.; from Cyprus Blue Book; and from the Cyprus Agr. Jour.

from the exports of raisins which averaged 9,327,000 pounds annually during the period 1925–1929. The total area under vines in that period averaged 89,148 acres a year but a large majority of this is devoted to the production of fresh grapes utilized for wine, the output of which has averaged about 4,000,000 gallons in recent years.[48]

PRODUCTION TREND

Table 22 gives the total area under vines in Cyprus and the exports of raisins from the island for a number of years. In general the raisin-growing potentialities of the island are not very great. Approximately one-half of the total area of Cyprus is under cultivation and only one-

[47] General sources used for this section in addition to those given in specific footnotes:
Cyprus Blue Book. Nicosia.
Cyprus Agricultural Journal, published quarterly.
Great Britain, Colonial Office. Colonial reports. Cyprus, published annually. London.

[48] Dawe, M. T. The grape and wine industry of Cyprus. Cyprus Dept. Agr. Industrial Series. Bul. 1:4. October, 1928.

fourth of the remainder is adaptable to agricultural pursuits. The ideal soils for successful cultivation of Sultanina vines are rather limited. This difficulty, however, may be partially overcome by grafting onto the local white grape "Xynisteri," which grows well on poor, dry lands, being deep-rooted and drought resistant.[49] Agriculture generally is

TABLE 23

CYPRUS RAISIN EXPORTS TO CHIEF MARKETS, 1913, 1920–1931

Calendar year	Total	Italy*	France	Rumania	Great Britain	Egypt	United States	Other countries†
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
1913	‡	§	§	6,684	11	635	797	‡
1920	4,067	125	470	§	711	915	1,074	772
1921	3,966	11	460	156	230	807	1,072	1,230
1922	4,040	168	976	243	208	287	1,564	594
1923	4,226	1,246	696	406	55	879	755	189
1924	10,274	5,568	1,334	1,023	94	672	1,245	338
1925	7,606	3,518	1,252	818	29	589	1,183	217
1926	7,400	4,226	1,268	965	241	284	377	39
1927	9,850	4,643	2,411	1,167	1,084	234	48	263
1928	10,906	5,205	3,772	1,092	340	269	§	228
1929	10,874	5,125	3,214	1,070	481	360	§	624
1930	11,553	6,764	2,281	807	257	299	§	1,145
1931	5,978	2,586	1,109	1,074	243	235	§	731

* Much of the increased shipments to Italy in recent years are believed to represent transit to Germany and other European markets.

† Direct exports of Cyprus raisins to Germany are given in official statistics for the following years only: 1924, 247,000 pounds; 1925, 11,000 pounds; 1928 35,000 pounds; 1929, 337,000 pounds; 1930, 945,000 pounds; 1931, 490,000 pounds.

‡ Total exports for the year 1913 are not available but total exports averaged 6,833,000 pounds for the five years 1909–1913. (See: Internatl. Yearbook of Agr. Statis., Rome.)

§ If any, included with "other countries."

Source of data: Compiled from Cyprus Blue Books.

undertaken by the peasant proprietors on small holdings. Since they are dependent upon yearly crops for their livelihood, they can hardly tie up land and capital in the production of a crop which will not bring returns until two or more years later. Even if prices are favorable, it is believed that expansion in the raisin acreage would take place very slowly. Much can be done to increase production, however, by improvement in methods of cultivation.

EXPORT OUTLETS

The ordinary Cyprus raisin has a tough skin and large pips and lacks flavor to some extent. For that reason it does not compete much with the bulk of eating raisins from other countries. At the present

[49] Agricultural Supplement No. 52 to The Cyprus Gazette. No. 2248. p. 1. October 28, 1932.

time, Cyprus raisins are used mainly for industrial purposes. Selected and well-prepared raisins are mostly consumed by the villagers themselves, while the export raisin is not given the same careful attention. Exports, however, have been increasing.

Table 23 shows that France, Italy, and Rumania take the bulk of the raisins exported from that island. Much of the increase in shipments to Italy in recent years is believed to represent transit trade for which Germany and other European markets are the ultimate destination. The German market probably receives its quota of Cyprus fruit through this transit trade.

Cyprus has been under British administration since 1878 and was declared a British Colony in 1925. For that reason it now enjoys preferential treatment in the British market. Exports to the United Kingdom, however, are relatively small because the Cyprus exportable product is not an edible raisin. There is a movement now among Cyprus exporters to develop the British market and make it an important outlet. With this end in view, the Cyprus Department of Agriculture for many years has been encouraging peasants to replace seeded raisin-grape vines with Sultanina vines. However, the area of this variety in 1932 did not exceed 28 acres and it is estimated that an increase of only about 7 or 8 acres of Sultanina vines is taking place annually.[50] At such a slow rate of growth it is evident that many years would be required to replace the present acreage of undesirable seed-raisin grapes with Sultanina vines. Hence, it would appear that there is little danger of sultana raisin exports from Cyprus becoming of any real importance in international trade for many years. Even if all of the present raisin-grape acreage of the island were ultimately replaced with Sultanina vines, raisin production would probably not exceed 10,000 tons. The Cyprus Department of Agriculture reports that yields per acre of sultana raisins in Cyprus are only from 2,000 to 3,000 pounds per acre as compared with 3,000 to 4,000 pounds in Greece and Smyrna. The Department, however, believes that good quality sultana raisins can be produced with proper cultural and processing methods.

[50] Agricultural Supplement No. 52 to The Cyprus Gazette. No. 2248. p. 1. October 28, 1932.

GOVERNMENT ASSISTANCE

Considerable legislation has been enacted in Cyprus dealing with plant protection, irrigation, coöperation, and credit.[51] The government also controls the sale of fertilizers in order to prevent misrepresentation and sells agricultural implements and selected seeds and plants at low prices. Progress in the cultivation of the Sultanina raisin grape is reported to have been accelerated by the establishment of a government nursery at the Saitta Experimental Vineyard from which growers can secure rooted cuttings at low prices.[52] Experiments are being made in numerous plots throughout the island to demonstrate proper methods of planting, fertilization, cultivation, pruning, irrigation, and drying. The Cyprus Department of Agriculture has from time to time carried out demonstrations in all the raisin-growing regions on the use of carbonate of potash solution as a dipping liquid with a view to improving the quality of raisins. This chemical hastens drying and gives the fruit a better appearance. It will be many years, however, before sufficient change in the ancient Cyprus raisin industry to be noticeable in international trade may be expected.

A number of their people have been trained abroad on government fellowships as experts for various branches of agriculture. Recently the government has sent Trade Development Missions to Syria, Palestine, Egypt, and Greece. The government has indicated that it does not favor the principle of subsidizing raisin growers by premiums or bounties which causes a rapid and perhaps unjustified expansion.

There is no legislation in force in Cyprus regulating the grading and packing of raisins. Such legislation may be enacted in the near future since the Empire Marketing Board in London reported unfavorably on several trial shipments of Cyprus raisins to that port and pointed out that expert grading and packing is the first requirement for successful marketing in the United Kingdom. It also recommended the production of sultana raisins in Cyprus rather than other kinds. It will be many years, however, before the results of this shift from the ancient Cyprus raisin to the more appreciated varieties become evident on the market.

[51] It is a remarkable fact that on this relatively small island with approximately 350,000 inhabitants mostly engaged in agriculture, there were on December 31, 1929, 320 coöperative societies, 223 being credit societies. The number of credit societies has increased until at present there are about 270. Fruit-preserving societies and tree (stock) planting societies are projected. Yearbook of Agr. Coöp. 1931:231. 1931. The Agricultural Bank, established in 1925 under the joint auspices of the government and the Ottoman Bank works in close connection with the coöperatives.

[52] Agricultural Supplement No. 52 to The Cyprus Gazette. No. 2248. p. 1. October 28, 1932.

THE RAISIN INDUSTRY OF PALESTINE, TRANSJORDANIA, AND SYRIA[53]

Most of the raisins produced in Palestine, Transjordania, and Syria are seeded varieties, largely from old vineyards in Syria and Transjordania and exported principally to Egypt. Palestine is said to ship the bulk of its grape crop fresh to Egypt. In addition to raisin grapes, Syria produces more wine grapes than table grapes. The district around the city of Es Salt is the chief raisin-producing section in Transjordania, and is estimated to produce about 1,984,000 pounds annually. The Palestine raisin industry is concentrated mainly in the Hebron district which is said to produce from 220,000 to 265,000 pounds of raisins annually. Viteles,[54] however, states that Palestine as a whole produces about 1,000,000 pounds a year. In the Hebron district most of the few sultana raisins produced are from young Thompson Seedless vines of California stock.

Syria, according to Shallah,[55] exports from 1,000,000 to 2,000,000 pounds of raisins annually, whereas table 24 shows that Palestine and Transjordania together have seldom exported more than 1,000,000 pounds through Palestine in any recent years. Shallah also states that Syrian raisins are mostly produced in the district around Damascus where the raisin-grape acreage has varied but little for many years because there is very little, if any, additional good raisin-grape land available for planting. The other grape-producing districts of Syria specialize in wine-grape growing. Shallah states that two chief kinds of raisin grapes are produced in Syria. Somewhat over half of the raisins produced are made from a long, finger-shaped, yellowish-white, seeded grape. Raisins from this grape are known as *Durbuly* in Syria. They are largely exported to Egypt where they are mistakenly spoken of as sultanas by the trade. Most of the balance of Syrian raisins are

[53] General sources used for this section in addition to those given in specific footnotes:

Palestine. Department of Customs, Excise and Trade. The Commercial Bulletin, published monthly. Jerusalem.

Palestine Economic Corporation, Inc. Annual reports. New York.

Palestine. Laws, Statutes, etc. Ordinances. Jerusalem.

[Palestine] Official Gazette, published fortnightly. Jerusalem.

The Palestine and Near East Economic Magazine, published fortnightly. Tel-Aviv.

[54] Viteles, H. B. Cultivation of grapes in Palestine. Palestine Econ. Soc. Bul. 3(3):1–87. 1928.

[55] The limited information on the Syrian raisin industry given in this section was secured from Mr. Anwar Shallah, a Syrian graduate student in the School of Commerce in the University of California in the 1932–33 school year, whose father is a prominent dried-fruit packer and exporter in Syria.

made from a small, red, seeded grape. These raisins are sometimes exported for wine-making.

Syria is a French protectorate and has its own Mediterranean ports, the chief one being Beirut. Transjordania is also an autonomous state not under the authority of the Palestine government, but it has no direct outlet to the sea and for that reason ships through Palestine. Most of the raisins reported in Palestine trade statistics as exported from Palestine are in reality shipments of the Transjordania product. Palestine

TABLE 24

EXPORTS OF PALESTINE AND TRANSJORDANIA RAISINS FROM PALESTINE, 1922–1932

Calendar years	Exports	Calendar years	Exports
	1,000 pounds		*1,000 pounds*
1922	604	1927	1,139
1923	467	1928	570
1924	997	1929	1,159
1925	403	1930	654
1926	285	1931	813
		1932	559

Sources of data:
1922–1924: from Viteles, H. Cultivation of Grapes in Palestine. Palestine Econ. Soc. Bul. **3** (3). 1928.
1925–1932: from The Commercial Bulletin.

contributes very few raisins to the export trade, her raisins being principally absorbed by the home market. In fact, Shallah reports that Palestine imports some Syrian raisins for local consumption. Table 24 gives the exports of Palestine and Transjordania raisins from Palestine from 1922 to 1932.

Approximately 90 per cent of the raisins exported from Palestine are shipped to Egypt, mostly to the port of Alexandria from which they are distributed to other parts of the country. The importance of Palestine's raisin industry in international trade is at present even smaller than that of the Cyprus raisin industry. But the potentiality of Palestine seems to be greater, when the probable acreage suitable and available is considered.

PRODUCTION PROSPECTS

Although there are no estimates of the area devoted to raisin production in Palestine all authorities seem to be of the opinion that it can be materially increased. One group in Palestine advocates concentration on the production of fresh table grapes, because the grapes ripen in July, like those of Imperial and Coachella valleys in California, which is much earlier than in the other grape-growing countries, and hence

they should find ready markets in Great Britain and other European countries. The Palestine Department of Agriculture has shown great interest in this branch of viticulture and has repeatedly arranged trial shipments of fresh grapes to Great Britain. The market advantage that very early, fancy table grapes usually have would lead one to believe that expansion of grape production for this purpose rather than for the production of raisins might be the better course to pursue at a time when world raisin supplies are normally so excessive and prices so low.

Another group, however, advocates an expansion of the raisin industry. Palestine has the advantage of long periods of sunshine with practically no rain during the drying season, which makes it particularly adaptable for raisin-grape growing. Furthermore, many varieties of raisin grapes can be grown on unirrigated land. The Rosakia (Elme) variety is one which thrives in the hills of Palestine, where much land is said to be available and no irrigation is required. Under such conditions, it is claimed that raisins can be more cheaply produced than in almost any other country. It is also claimed that the Muscat produces better yields and quality in Palestine than in Spain, and would take preference over Spanish raisins because of its higher sugar content. Moreover, it can be placed on the market earlier. Varieties other than the Muscat are said to be preferred for raisin wine-making by Jews living in foreign countries. A further argument for the expansion of the raisin industry rather than the fresh-grape industry is that in countries where "Prohibition" is the law, and in those countries having a government monopoly, raisins are used to some extent for making wine at home; the Rosakia variety is used for that purpose.

Trial consignments of Palestine raisins have been made to the Imperial Economic Committee in London. The experts reported favorably on the quality and flavor of the raisins, but found that the fruit was not free from foreign matter and that it was not properly graded and packed.

GOVERNMENT ASSISTANCE

No particular measures for rapid and artificial expansion of the raisin industry have been taken. It will be necessary for Palestine to test carefully the adaptability of certain varieties for cultivation and markets, before raisin growing is promoted. As most of the vineyards in Palestine belong to Arabs, the government will encourage the industry only if there is a prospect of a good market outlet. In any event officials take the attitude that the industry should develop gradually by itself and should not be expanded artificially. It is safe to say that, even if encour-

agement should be decided upon by the government, it would take a long time to make Palestine an important competitor.

The industry has, however, been favored by the formation of a plant-protection service (1924) requiring that all nursery vine stocks be subjected to inspection and fumigation and prohibiting the importation of plants from Egypt (1924) and Syria (1926). On the other hand, vines of American stock can be imported duty free (1924–1927) as well as supplies and equipment for the destruction of plant pests and other agricultural operations (irrigation material, tools, fertilizers, etc.). Since 1926 no export duty has been charged upon any goods exported. Vineyards planted with American stock were freed from the necessity of paying land taxes for a ten-year period, 1920–1929.

As much land is held under tenancy in Palestine, the formation of a board in 1930 for the protection of the tenant in case of dispute with the landowner, is considered a factor of real benefit to the raisin grower. The reason for the establishment of this board was that no tenant showed interest in land improvement or in the planting of new vineyards because there was no provision of law entitling him to compensation in case he had to leave the holding. At the present time a compensation has to be paid. The amount is determined by the board. This regulation will undoubtedly induce tenants to make new plantings and to improve the existing ones.

A committee consisting of government officials and representatives of private organizations was formed in 1927 to act in an advisory capacity on all matters pertaining to the marketing of table grapes. It is believed that such a committee will be set up sooner or later to cover raisins. The Palestine Department of Agriculture since 1927 has been conducting experiments in the drying of grapes from local varieties, while the Department of Agricultural Colonization of the Palestine Executive of the Jewish Agency for Palestine (formerly the Palestine Zionist Executive) is investigating the use of Muscats for cluster raisins. While practically none of the measures above mentioned are of much significance either for the promotion of the Palestine raisin industry or for the international raisin trade, they show a definite improvement in the official attitude towards farmers. The old hindrances to progress are being removed so that the raisin industry now has a chance to grow up by its own effort.

THE ITALIAN RAISIN INDUSTRY[56]

Although natural conditions in Italy would seem to make that country an excellent region for raisin and currant production, the industry has not developed into commercial importance. The Italian raisin and currant output, however, is not without significance as regards the competitive aspects of the world market, because Italy consumes several thousand tons of raisins and currants produced at home, which otherwise might be imported from foreign producing centers.

PRODUCTION TREND

Eisen[57] stated that in 1890 three sections of the Italian kingdom together produced 15,000 tons of raisins and currants which would be 5,000 tons more than California produced at that time. These sections were Calabria, and the islands Lipari (north of Sicily) and Pantelleria, between Sicily and the northern African coast. Giglioli[58] reports that in the period 1897 to 1902 average imports of raisins and currants were about six times as large as exports, indicating that home production did not satisfy the demand although a comparatively large amount was produced. Briganti,[59] in 1919, stated that raisin production assumed the characteristics of a real industry only on the islands of Pantelleria and Lipari, which produced together about 5,500 tons. In a more recent statement,[60] it was estimated that Italian production of raisins for these two islands was between 6,600 and 7,200 tons, with production in Calabria no longer of any commercial significance. Another estimate[61] in 1927

[56] General sources used for this section in addition to those given in specific footnotes:

American Chamber of Commerce for Italy. Year Book. Milan. 1930.

Confederazione Nazionale Fascista Agricoltori, Commissione Tecnica per le Uve da Tavola. Le Uve da Tavola. [The table grape.] 50 p. Societa Anonima Stabilimento Arti Grafiche, Milan. 1930.

[Italy] Gazzetta Ufficiale, published daily. Rome.

Istituto Nazionale per l' Esportazione. [The Italian Exporter.] Published monthly. Rome.

L'Italia Agricola, published monthly. Piacenzo.

L'Italia Vinicola ed Agraria, published weekly.

[57] Eisen, Gustav. The raisin industry. p. 177. H. S. Crocker and Company, San Francisco. 1890.

[58] Giglioli, Italo. Di alcune vere questioni meridionali. (Extract from: Revista d'Italia.) p. 17. July, 1903.

[59] Briganti, Gaetano. I Problemi dell aboricoltura Italiana. L'Italia Nuova. Series No. 3:40. 1919.

[60] Giornale di Agricoltura. p. 489. (Picenza) 1927.

[61] Casella Domenico, in: Relazioni del II Congresso Nazionale di Frutticoltura. 1927:304. (Ravenna) 1928.

places the raisin and currant production of Italy at from 5,500 to 6,600 tons.

The islands of Pantelleria and Lipari are both under the administration of Sicily, Lipari belonging to the province of Messina and Pantelleria to Trapani. Most of the raisins listed in the production statistics as being produced in Sicily actually come from the island of Pantelleria.

TABLE 25

ITALIAN RAISIN PRODUCTION BY DISTRICTS, 1929–1932

Administrative districts and regions	1929		1930		1931		1932*	
	Fresh grapes destined to raisin production	Raisins produced	Fresh grapes destined to raisin production	Raisins produced	Fresh grapes destined to raisin production	Raisins produced	Fresh grapes destined to raisin production	Raisins produced
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Central Italy:	3,021	1,057	5,425	1,900	4,046	1,349	3,212	1,122
Marche	7	3	4	2	62	22	57	20
Latium	3,014	1,054	5,421	1,898	3,984	1,327	3,155	1,102
Southern Italy:	438	147	322	105	1,221	402	1,040	343
Abruzzi and Molise	317	101	201	64	335	107	337	108
Apulia	99	33	101	34	112	38	141	48
Calabria	22	13	20	7	774	257	562	187
Islands:	30,593	10,476	22,681	7,610	20,242	6,624	18,775	5,922
Sicily	29,217	10,004	20,750	6,960	18,534	6,042	17,002	5,322
Sardinia	1,376	472	1,931	650	1,708	582	1,773	600
Total Italy	34,052	11,680	28,428	9,615	25,509	8,375	23,027	7,387

* Preliminary data subject to revision.

Source of data:
Istituto Centrale di Statistica, Bolletino Mensile di Statistica Agraria e Forestale, January, 1931, and December, 1932.

Raisin and currant production on the island of Sicily itself has not been developed on a commercial scale. Table 25 gives the official production statistics for Italian raisins for the years 1929–1932. The bulk of the commercial production, amounting to from 10 to 12 million pounds, is marketed mainly in the industrial centers of northern Italy, especially in Milan, a growing outlet.

The raisin grapes, Zibibbo, grown in the main producing region, Pantelleria, are the Muscat of Alexandria and are marketed mainly as cluster raisins. In quality they are inferior to the Spanish product. The island of Lipari produces a type of seedless currant (Passolina di Lipari), which is larger in size than the Greek currant and has a tough

skin. The production in other regions consists exclusively of seeded raisins.

The practice of processing raisins and currants varies considerably in the different producing regions.[62] It is generally recognized in the Italian literature on the subject, that processing is executed very primitively and that the product would be much better if it were processed scientifically and better graded and packed.

MARKET OUTLETS AND DOMESTIC CONSUMPTION

Italy exports only small quantities of raisins (see table 26). These exports are fairly well distributed to all European countries, but the

TABLE 26

RAISIN AND CURRANT EXPORTS FROM ITALY, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Exports	Calendar year	Exports
	1,000 pounds		*1,000 pounds*
Average:		Annual (*continued*)	
1909-1913	369	1925	82
		1926	95
Annual:		1927	30
1920	210	1928	13
1921	423	1929	114
1922	98	1930	106
1923	113	1931	156
1924	485	1932	130

Sources of data:
Internatl. Yearbook Agr. Statis., Rome: Statistica del Commercio Speciale; Movimento Commerciale del Regno d'Italia.

bulk goes to the United States. It seems that the Italian people living in certain large centers of population in the United States do not like to miss the genuine *Pantelleria* in Christmas dried-fruit baskets.

Imports of raisins and currants into Italy are shown by the data in table 27 to have been increasing steadily since the War. In 1930 they amounted to 5,951,000 pounds as compared with an average of 2,795,000 pounds for the years 1909–1913. Comparison of imports with production indicates that Italy produces, on the average, considerably more raisins than she imports. The question, therefore, arises why could not Italy herself satisfy the increasing demand at home that is indicated by imports? The increase in imports is due to the inferior quality of the Italian raisins and to the fact that during the last four years a superior product from abroad has been offered at favorable prices.

[62] A comprehensive statement to this effect is given by: Casella Domenico in: Relazioni del II Congresso Nazionale di Frutticoltura 1927:304. (Ravenna) 1928.

PROSPECTS FOR THE INDUSTRY

An expansion in production would seem to depend largely upon an improvement in the quality of the product. If the Italian producers could improve the quality of their raisins and currants without raising prices to more than slightly under the level of those of foreign origin there is no question but that, under present consumption conditions, an additional 3 to 5 million pounds of home-grown produce could be marketed, largely in the cities, as a substitute for imports from abroad. This would necessitate, however, more of an increase in the production of currants and other seedless raisins than of Zibibbo (Muscat) raisins.

TABLE 27

ITALIAN IMPORTS OF RAISINS AND CURRANTS, AVERAGE 1909–1913, ANNUAL 1920–1932

Calendar year	Imports	Calendar year	Imports
	1,000 pounds		*1,000 pounds*
Average:		Annual (*continued*):	
1909-1913	2,795	1925	2,780
		1926	1,557
Annual:		1927	6,372
1920	351	1928	7,821
1921	1,083	1929	4,657
1922	1,137	1930	5,951
1923	2,950	1931	5,538
1924	3,341	1932	5,976

Sources of data:
Internatl. Yearbook Agr. Statis., Rome: Statistica del Commercio Speciale; Movimento Commerciale del Regno d'Italia.

A considerable, but unknown, quantity of home-dried raisins is consumed in Italy, largely by farmers. Therefore, total consumption of raisins in Italy is not known. Consumption of commercial raisins (other than home-dried), however, averages about ½ pound per capita. It would probably be very difficult to double the per-capita consumption of commercial raisins produced in Italy since the bulk of the demand is for holiday trade. Other fruits are abundant and cheap, and but few of the rural population could be induced to substitute commercially dried raisins for home-dried. The demand for raisins in Italy is highly seasonal since they are used mainly as an ingredient of holiday cake (*panettone*) or in cluster form at Christmas. During the rest of the year the raisin is not a daily foodstuff and is not likely to become one. There is an abundance of fresh, as well as of dried fruit, especially figs, which, so far as the daily diet is concerned, strongly competes with raisins in Italy.

Most of the peasants who grow grapes dry some at home for consumption at Christmas time. Even some city dwellers purchase fresh grapes for the same purpose. Such home-dried raisins have a peculiar tart flavor seemingly well liked by the consumers, and in addition are cheaper than commercial raisins. Undoubtedly the general use of home-dried raisins by farmers plays an important part in checking the commercial expansion of the commercial raisin industry. Nevertheless, it does not seem unreasonable to assume that the Italian raisin industry could expand to a production level of about 25 million pounds for home consumption, provided it shifts to growing seedless varieties. Considerable land is available for raisin production on the sea-coast mountain slopes and foothills of Sicily and southern and central Italy, and a considerable area of land in wine grapes now unprofitable as a result of overproduction of wine might be used for raisin production.

GOVERNMENT ASSISTANCE

In view of the well-known endeavors of the Fascist régime to develop and to encourage agriculture in general, it is surprising that the raisin industry has received no specific official encouragement—not even a protective tariff.[63] One measure, however, which might contribute to an increase in the production of seedless varieties is the decree of December 31, 1923. This decree exempted new plantations of "high-growing vines" (espaliers, tree-trained, or stake-supported, trellised, branched and the like) from payment of taxes.

THE SPANISH RAISIN INDUSTRY[64]

The Spanish raisin industry centers in two districts bordering on the Mediterranean Coast. The southern district is in Málaga, of which Málaga is the chief port; the northern district is in the provinces of Valencia and Alicante, of which Denia is the chief port. Sporadic attempts have been made to produce raisins in Almería, Tarragona,

[63] For a discussion of the governmental policy of Italy toward agriculture in general see: Hazan, N. W. The agricultural program of the Fascist Italy. Jour. Farm Econ. 15:489–502. 1933.

[64] General sources used for this section in addition to those given in specific footnotes:

Agricultura; Rivista Agropecuaria, published monthly. Madrid.

American Chamber of Commerce in Spain. Bulletin, published monthly. Barcelona.

La Pasa de Málaga. Málaga.

Livengood, C. A., Julian Greenup, and Philip M. Copp. Spain: resources, industries, trade, and public finance. U. S. Dept. Com. Bur. of Foreign and Dom. Com. Trade Inform. Bul. 739:1–47. 1930.

[Spain] Dirección general de agricultura. Boletín de agricultura técnica y economica, published monthly. Madrid.

Granada, Córdoba, and on the Canary Islands. With the exception of negligible quantities produced in the provinces of Granada and Córdoba, however, no raisins are grown in other parts of Spain. The raisin

TABLE 28

SPANISH EXPORTS* OF RAISINS, TOTAL, AND FROM THE VALENCIA-ALICANTE AND MÁLAGA DISTRICTS, 1905–1912, 1921–1932

Year†	Valencia-Alicante‡ (unofficial)	Málaga (unofficial)	Total, Valencia-Alicante and Málaga (unofficial)	Total Spain (official)
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
1905	52,317	15,293	67,610	66,678
1906	32,804	11,266	44,070	44,359
1907	49,846	14,976	64,822	60,315
1908	44,233	12,555	56,788	58,149
1909	48,719	12,815	61,534	64,758
1910	38,197	12,718	50,915	56,514
1911	41,574	18,256	59,830	62,347
1912	25,027	12,053	37,080	38,090
1921	13,684	21,996	35,680	38,734
1922	18,456	19,626	38,082	34,289
1923	16,358	16,571	32,929	27,313
1924	22,730	19,270	42,000	37,822
1925	26,814	19,905	46,719	37,922
1926	22,512	13,503	36,015	39,676
1927	23,556	16,186	39,742	39,277
1928	19,498	14,182	33,680	30,504
1929	19,046	12,784	31,830	30,870
1930	18,822	12,640	31,462	32,800
1931	16,700	12,548	29,248	30,684
1932§	17,226	14,100	31,326	31,063

* Data for the Valencia-Alicante and Málaga districts, 1921–1931, and presumably all data for total Spain exclude shipments by sea to Spanish markets. It is not known whether or not such shipments are included in the data for the Valencia-Alicante and Málaga districts previous to 1921.

† All data 1905–1912 and data for total Spain are for calendar years. Data for the Valencia-Alicante district, 1921–1928, are for years beginning July 1; and 1929–1932, for years beginning August 1. Data for the Málaga district, 1921–1928, are for years beginning September 1; and 1929–1932, for years beginning August 1.

‡ Data for 1905–1912 are on exports from the port of Denia only, which amounted to 42,560,000 pounds in the calendar year 1904 and for crop years 38,173,000 in 1913, 28,467,000 in 1914 and 11,776,000 in 1915. Data on exports from the ports of Valencia and Alicante, the other ports from which raisins of this district are shipped, are not available previous to 1913, but for the three crop years 1913–1915 averaged only 6,660,000 pounds.

§ Preliminary estimates subject to revision.

Sources of data:

Data for the Valencia-Alicante district for 1905–1912: compiled from Great Britain Diplomatic and Consular Reports on the Trade and Commerce of the Consular District of Barcelona, Spain. 1921–1928: compiled from Exportacion de Pasa Valenciana. 1929–1932: from U. S. Agricultural Commissioner, N. I. Nielsen, Marseilles, France. (See: Federal-State Market News Service. Foreign Raisin Reports No. **39**: 3, 4; No. **45**:2. March and August, 1933 [Mimeo.] Sacramento, California.)

Data for the Málaga district 1905–1912: compiled from Great Britain Diplomatic and Consular Reports on the Trade and Commerce of the Consular District of Málaga, Spain. 1921–1932: from table 33.

Data for total of Spain from table 32.

industry in Spain is not of the same economic importance to the country as a whole as it is in other countries of the Mediterranean, although it is of vital importance to the population in the main producing districts.

The raisin grapes grown in Spain are almost exclusively the Muscat

(Gordo Blanco) variety.[65] However, the raisins of the two chief producing regions differ from each other greatly in that the Muscats of Málaga, known as Málaga raisins,[66] are exported mainly as clusters, while the Valencia and Alicante output is all sold off the stalk. This is due to the fact that simple sun-drying of the bunches can take place in Málaga, while dipping in a soda and lye solution must be practiced in the other districts because the climate makes sun-drying difficult. This procedure makes the raisins from Valencia and Alicante inferior to those from Málaga. Soil conditions in the Valencia-Alicante district are also said to influence the quality of the product grown in that district. The decided difference in the consumptive use to which the cluster Muscats from Málaga and the loose Valencia-Alicante product are put makes two rather distinct raisin industries in Spain, since the product of the two regions is practically noncompetitive.

TREND OF PRODUCTION

According to Eisen,[67] the Spanish raisin industry originated in ancient times. After a period of apparent deterioration under the Roman rule, raisin growing in Spain is supposed to have been reëstablished and improved by the Arabs and Moors. At times the output of the Valencia raisin industry must have been remarkable. Eisen further stated that by 1862 raisin exports from Valencia had dwindled to 14 million pounds.[68] By 1876 exports had again risen to 38 million pounds and by 1883 to 80 million pounds. In 1888 the output[69] was about 64¾ million pounds. The crop of 1889 is reported to have reached nearly 78½ million pounds (converted from Eisen's figures of "2,800,000 boxes of 28 pounds each"). Table 28 shows that the Valencia district averaged about 44¾ million pounds in 1905–1908. Since then exports from that district have

[65] Wheeler says: "A relatively small amount of Lairen and Pedro Ximen raisins are also produced in Málaga." (From: Wheeler, L. A. International trade in dried fruits. U. S. Dept. Com. Bur. Foreign and Dom. Com. Trade Promotion Series No. 44:10. 1927.) According to reports from the United States Consular sources, the last two varieties represent about one-fifth of the total raisin output of Málaga. These raisins do not enter to any important extent into the export trade. They are mostly consumed within the country in the production of wine and alcohol. The small amounts exported go mainly to Mexico and South America.

[66] This is the Gordo Blanco Muscat of Málaga which is the same as the California Muscat (Muscat of Alexandria). The California Malaga grape is a different variety.

[67] Eisen says that raisins are known to have been exported from Málaga since 1295 A. D., and that raisins were being produced in Spain many centuries before that date. The raisin-producing areas in Spain were settled by the early Phoenecian traders and it is believed that they introduced the production of raisins in Spain. Records indicate that the Valencia raisin was known to the Romans. (From: Eisen, Gustav. The raisin industry. H. S. Crocker and Company, San Francisco. 1890.)

[68] Converted from supposedly short tons.

[69] Probably the combined output of Valencia and Alicante.

dwindled to only about one-half of that quantity, averaging only a little over 20 million pounds in the years 1926–1930. From these data it would appear that the raisin industry in the Valencia district is capable of great expansion.

The output of the raisin industry of Málaga also seems to have decreased greatly. Exports from Málaga declined from an average of

TABLE 29

FRESH GRAPES DESTINED FOR RAISIN PRODUCTION IN SPAIN, 1907–1927

Year harvested	Quantity		Year harvested	Quantity	
	Fresh weight	Equivalent dry weight		Fresh weight	Equivalent dry weight
	1,000 pounds	*1,000 pounds*		*1,000 pounds*	*1,000 pounds*
1907	164,952	41,238	1918	98,914	24,728
1908	159,490	39,875	1919	165,868	41,467
1909	188,172	47,043	1920	172,188	43,047
1910	102,348	25,587	1921	142,692	35,673
1911	164,946	41,237	1922	132,990	33,248
1912	114,248	28,562	1923	113,324	28,331
1913	175,736	43,934	1924	180,600	45,150
1914	112,310	28,078	1925	184,222	46,056
1915	87,194	21,798	1926	125,012	31,253
1916	148,000	37,000	1927	205,608	51,402
1917	144,012	36,003			

Sources of data:
Fresh weight from Junta Consultiva Agronomica (since 1923, Consejo Agronomico) in Estadistica Viticola y Olivarera, 1907–1915, and Estadistica de la Produccion Viticola, 1926–1927. Dry weight computed from fresh weight at a drying ratio of 4 to 1.

about 48 million pounds in the years 1870–1874 to only about 14 million pounds in the years 1926–1930.

Up to the present time there have been no official Spanish statistics on the acreage and production of raisins for a series of years. It is believed, however, that such data will be available in the future in view of the fact that a royal decree of November 14, 1929, provides for the compilation of agricultural statistics. Official statistics covering the quantities of fresh grapes destined to be worked into raisins are available from 1907 to 1927 (see table 29), but they are not given separately for each province until 1921 (table 30). Sporadically the government has also issued official figures on the production of raisins in the principal producing regions. Comparison of these data and those in table 30 on the quantities of fresh grapes destined for raisin production, converted to a dried basis, indicate that the latter probably are a rough approximation of the actual raisin production of Spain. However, in a few years, mostly pre-war years, the dried production shown in table 29 has been

somewhat smaller than the quantity shown in table 32 as actually exported from Spain. In years since the War, the apparent dried production of Málaga shown in table 30 is greater than exports for corresponding years (table 28), but the apparent production of the Valencia-Alicante district shown in table 30 is smaller than exports in

TABLE 30

Grapes Destined for Raisin Production in Spain by Provinces, 1921–1927

Province	1921	1922	1923	1924	1925	1926	1927
	1,000 pounds, fresh weight						
Málaga	93,682	87,236	63,574	134,210	132,200	95,556	143,334
Valencia and Alicante	48,934	45,690	49,682	46,318	51,942	29,336	62,148
Valencia	9,250	9,314	9,998	9,942	12,258	5,966	34,590
Alicante	39,684	36,376	39,684	36,376	39,684	23,370	27,558
Grenada	66	64	68	72	80	76	84
Córdoba	—*	—	—	—	—	44	42
Total	142,682	132,990	113,324	180,600	184,222	125,012	205,608
	1,000 pounds, equivalent dry weight						
Málaga	23,421	21,810	15,894	33,552	33,050	23,888	35,834
Valencia and Alicante	12,234	11,422	12,420	11,580	12,986	7,334	15,538
Valencia	2,312	2,328	2,500	2,486	3,064	1,492	8,648
Alicante	9,922	9,094	9,920	9,094	9,922	5,842	6,890
Grenada	16	16	18	18	20	20	20
Córdoba	—	—	—	—	—	10	10
Total	35,672	33,248	28,332	45,150	46,056	31,252	51,402

* Dashes indicate data not available.

Sources of data:
Fresh weight from official Spanish sources.
Dry weight calculated from fresh weight at a drying ratio of 4 to 1.

every year from 1921 to 1927 inclusive (table 28). The export data should be more reliable than the data on raisin grapes destined for drying since exports presumably represent rather closely the actual movement out of the country, and in some years, also include the movement by sea to Spanish markets in addition to shipments to foreign countries.

The United States Department of Agriculture now maintains a representative (see footnote 27, page 38), one of whose duties is to gather from personal observation, as well as from contacts with the governments and the trade, the most reliable estimates of the various fruit and nut crops produced in the countries of the Mediterranean basin.

Table 31, which is based on the investigations made by this representative, gives what is believed to be the most accurate information available on the raisin production in the principal growing regions of Spain in recent years.

EXPORT TRADE AND ITS PROSPECTS

The official statistics of Spanish exports of raisins are unsatisfactory. In the first place they do not make a distinction between clusters and loose raisins. In the second place, the official export statistics are frequently lower than those reported by the trade, probably because of the methods

TABLE 31

RAISIN PRODUCTION IN SPAIN, 1929–1933

Crop year harvested	Valencia district	Málaga district	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
1929	24,712	16,690	41,402
1930	19,362	15,786	35,148
1931	17,200	15,100	32,300
1932	18,700	22,000	40,700
1933*	5,800	15,200	21,000

* Preliminary data subject to revision.

Source of data:
U. S. Agricultural Commissioner, N. I. Nielsen, at Marseilles, France. (See: Federal-State Market News Service, Foreign Raisin Reports. [Mimeo.] Sacramento, California.)

employed in exporting during the rush season. Table 28 enables one to compare the official and unofficial figures for most years since 1905. In order to compare changes in raisin exports from the Málaga with those from the Valencia-Alicante district, it has been necessary to depend largely on the unofficial data shown in table 28. Significant differences between the raisin industries of the two districts make such comparison desirable. The Málaga industry faces entirely different competitive conditions from those faced by the Valencia-Alicante industry. Raisins from Málaga are marketed in clusters as far as possible and are considered a specialty product of unique characteristics. They are sought after by the holiday trade. The Valencia-Alicante raisin district, on the other hand, does not produce cluster raisins, and its export trade in loose raisins has had to face the problem of a decreasing export demand.

Declining Exports from Valencia-Alicante.—Tables 33 and 34 indicate that Muscats from Málaga have a much wider distribution than exports from the Valencia-Alicante district, and the principal consuming markets generally seem to take a steady percentage of the total

exports. The Valencia-Alicante raisin is losing more ground on the international raisin market than the Muscat of Málaga although the quantities exported from Valencia-Alicante are larger than those exported from Málaga. The fact that the Valencia-Alicante district is not in a position to produce clusters will, in all probability, prove rather detrimental to its further trade development, especially in view of the preference given by consumers to seedless varieties. Unless the Valencia-

TABLE 32

Raisin Exports from Spain, 1891–1932

Calendar year	Exports	Calendar year	Exports	Calendar year	Exports
	1,000 pounds		*1,000 pounds*		*1,000 pounds*
1891	63,750	1905	66,678	1919	49,489
1892	82,190	1906	44,359	1920	58,220
1893	60,227	1907	60,315	1921	38,734
1894	71,486	1908	58,149	1922	34,289
1895	64,119	1909	64,758	1923	27,313
1896	65,988	1910	56,514	1924	37,822
1897	70,223	1911	62,347	1925	37,922
1898	74,533	1912	38,090	1926	39,676
1899	78,801	1913	42,543	1927	39,277
1900	81,054	1914	33,535	1928	30,504
1901	69,623	1915	25,583	1929	30,870
1902	61,951	1916	42,977	1930	32,800
1903	68,470	1917	18,878	1931	30,684
1904	58,779	1918	36,966	1932	31,063

Sources of data:
1891–1906: compiled from Great Britain, Statistical Abstract for Foreign Countries.
1907–1932: compiled from Resumenes Mensuales de la Estadistica de Comercio Exterior and Estadistica General del Comercio Exterior de España.

Alicante district goes over gradually to the production of sultana raisins a further decline of exports may be expected. However, the decline of the industry in this region has taken place so slowly that growers have had time to shift to other crops, mainly oranges.[70]

Exports from Málaga.—Málaga, on the other hand, has the advantage of being able to produce a specialty product, for which there will probably always be a limited demand. The production of cluster raisins in California is relatively small and exports have been negligible in recent years. Buyers in the United Kingdom and on the Continent depend on Málaga as the main source of supply. Moreover, it would be difficult for other producing countries to overcome Spanish competition, for the preparation of clusters demands much skilled hand labor which is plen-

[70] Nielsen, N. I. U. S. Agricultural Commissioner, Marseilles, France, stated in reply to a questionnaire of January 24, 1931 ". . . . in (the district around) Denia and Alicante it is believed that the industry is decreasing because it seems impossible to produce at a price to be able to compete with other producing countries. Furthermore, it has been found more profitable to produce other crops such as oranges, the acreage of which is on the increase."

TABLE 33

RAISIN EXPORTS FROM MÁLAGA, SPAIN, BY COUNTRIES OF DESTINATION, 1921–1931
(Years beginning September 1)

Country of destination	1921	1922	1923	1924	1925	1926	1927	1928	1929*	1930*	1931*
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom	5,144	5,631	5,193	5,051	4,873	3,681	4,986	3,434	3,284	3,516	3,618
France	2,635	3,203	2,153	3,723	3,831	1,985	2,703	3,151	2,696	3,428	3,480
United States	4,748	2,325	1,278	1,819	2,088	920	868	914	452	654	618
Sweden	1,960	1,819	1,637	1,531	1,771	1,079	1,117	743	712	634	822
Denmark	2,416	1,404	951	888	850	571	591	400	278	316	374
Germany	1,314	246	428	1,175	801	676	782	659	788	806	556
Netherlands	677	890	764	782	683	387	443	532	504	618	582
Belgium	838	579	681	438	836	614	1,023	1,018	730	584	658
Mexico	680	537	509	322	423	348	276	106	—†	—	—
Uruguay	479	405	276	509	467	384	646	384	558	294	308
Cuba	389	953	955	885	1,140	695	540	382	378	230	140
Brazil	164	219	329	516	632	877	782	944	900	466	438
Canada	91	452	355	399	565	318	329	390	250	218	248
Argentina	153	333	364	253	245	154	100	130	—	—	—
Portugal	128	35	158	83	143	185	135	205	172	150	110
Italy	108	84	239	413	266	167	427	435	336	188	122
Norway	60	365	196	334	196	169	237	96	—	—	—
Other countries	12	146	105	149	95	293	201	259	746	538	474
Total to foreign markets	21,996	19,626	16,571	19,270	19,905	13,503	16,186	14,182	12,784	12,640	12,548
To Spanish markets by sea	—	1,174‡	1,384‡	2,019	2,363	3,589	4,336	4,749	3,906	3,146	2,226
Grand total	—	20,800‡	17,955‡	21,289	22,268	17,092	20,522	18,931	16,690	15,786	14,774

* Data for 1929-1931 are for years beginning August 1.

† Dashes indicate data not available.

‡ Data on shipments to Spanish markets by sea, 1922 and 1923, are for calendar years.

Sources of data:

Data 1921–1928 on exports to foreign markets from United States Consul at Málaga who secured data for all countries but United States from the Muscatel Raisin Defense Council of Málaga. Data on exports to the United States taken from the United States Consul's own records. Shipments by sea to Spanish markets compiled from United States consular reports. Data not available for 1921. All data for 1929–1931 compiled by United States Agricultural Commissioner's office at Marseilles, France. (See: Federal-State Market News Service, Foreign Raisin Report No. **39**: 14. March, 1933. [Mimeo.] Sacramento, California.)

TABLE 34

RAISIN EXPORTS FROM THE VALENCIA-ALICANTE DISTRICT* OF SPAIN BY COUNTRIES OF DESTINATION, 1921–1931
(Years beginning July 1)

Country of destination	1921	1922	1923	1924	1925	1926	1927	1928	1929†	1930†	1931†
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom	12,351	15,929	10,834	14,305	16,098	14,384	14,836	9,941	11,342	11,928	10,188
Irish Free State	29‡	14‡	123‡	382	105	305	769	580	§	§	§
Finland	—	838	1,588	2,000	3,992	2,431	2,992	2,098	1,808	1,146	1,030
Italy	—	—	—	—	—	—	697	2,315	804	1,400	1,604
France	450	169	402	1,398	1,959	1,844	1,695	1,697	1,448	1,554	1,754
Algeria	36	224	475	806	853	437	706	1,305	1,328	848	544
United States	180	429	426	339	327	188	498	437	328	308	190
Sweden	27	39	397	115	102	404	72	32	124	52	52
Norway	74	127	476	1,046	1,176	1,265	544	323	556	500	748
Canada	326	515	659	1,285	1,169	540	215	268	276	278	106
Denmark	15	30	412	136	201	126	65	19	14	30	—
Germany	—	—	410	211	253	176	186	34	100	66	34
Belgium	—	—	73	3	32	59	184	103	318	306	286
Switzerland	192	133	74	701	349	244	53	52	16	2	22
Other countries	4	9	9	3	198	109	44	294	584	404	142
Total to foreign markets	13,684	18,456	16,358	22,730	26,814	22,512	23,556	19,498	19,046	18,822	16,700
To Spanish markets by sea	1,942	1,764	1,587	3,207	3,376	1,696	6,376	6,917	5,666	540	416
Grand total	15,626	20,220	17,945	25,937	30,190	24,208	29,932	26,415	24,712	19,362	17,116

* Includes exports from Valencia, Alicante, Castellon de la Plana, and Murcia.

† Data for 1929–1931 are for years beginning August 1.

‡ Ireland.

§ Included in "other countries."

Sources of data:

1921–1928; from "Exportacion de Pasa Valenciana" except for exports to Spanish markets, 1926–1928, which are from United States Consular reports. Data in quintals converted to pounds at 112 pounds per quintal, the factor indicated in "Exportacion de Pasa Valenciana."

1929–1931: from reports of United States Agricultural Commissioner N. I. Nielsen, Marseilles, France. (See: Federal-State Market News Service, Foreign Raisin Report No. **39**:13. March, 1933. [Mimeo.] Sacramento, California.)

tiful and cheap in Spain. Other countries with abundant cheap labor (Palestine, Cyprus, Union of South Africa) can hardly be expected to produce clusters of a quality equal to that of the Spanish. The long-time outlook for the cluster Muscat of Málaga, therefore, appears favorable for a limited tonnage for export.

The entire Spanish raisin industry has been in a rather satisfactory position when compared with that of Greece and Turkey, because there has practically never been a great discrepancy between production and exports. The carryovers from old crops have always been negligible, if not exhausted at the time the new crop comes on the market. This is partly due to a considerable increase in home consumption in Spain since 1924.

Domestic Raisin Consumption.—Domestic consumption of raisins in Spain in the years 1928–1930 was several times greater than five or six years previous, the Valencia-Alicante region taking a greater share in this increase. In 1930 about 10,000,000 pounds of raisins from both of the Spanish producing areas were consumed in Spanish markets. This would correspond to a per-capita consumption of about 0.45 pound. It is reported[71] that in 1929, 10,572,000 pounds of raisins were used locally for industrial purposes; in 1930, however, only about 5,000,000 pounds. In other words, the per-capita consumption of raisins used as a foodstuff in 1930 would be only about half of the figure stated above. But this is a point in favor of the Spanish raisin industry, since it indicates that the population of Spain could absorb more for eating purposes than it does at present.

Fresh-Grape Outlets.—At times in recent years there has been an increased demand in Spain for fresh grapes, which have been shipped from Málaga into the interior of Spain on trucks. Moreover, foreign countries have also shown a demand for fresh grapes, according to the varying outcome of their own and other fresh-fruit crops. The Muscat, having large berries, is adapted to consumption in the fresh state and the industry can depend fairly well on this outlet in times of threatening raisin overproduction. In fact the demand for fresh grapes has at times reduced the raisin output, although no disastrous overproduction of raisins was in view.

PROMOTION OF RAISIN GROWING

Although one of the features of the post-war economic policy in Spain has been the increasing government intervention in, and reorganization of, agriculture, the raisin industry has been the recipient of little direct

[71] Nielsen, N. I. U. S. Agricultural Commissioner, Marseilles, France. January 13, 1931.

government aid. There is, of course, the usual amount of plant protection, agricultural extension, credit, coöperative and other legislation affecting agriculture in general, but these legislative measures have not promoted raisin growing any more than they have other branches of agriculture. At any rate, it has not been the tendency of the government to pay premiums on exports or new plantings. On the contrary, a decree of April, 1926, granted exemption from all production taxes to owners of land who would use the land then under vines for the cultivation of cotton. This measure, however, had practically no effect on raisin growing. It was primarily intended to check expansion of wine production, but it is mentioned here as one indication of the attitude of the government toward vine culture in general.

The Spanish government, however, has given special attention to the promotion of agricultural exports in general which has been of help to the raisin industry. An export credit bank, for example, was formed in the fall of 1928 for the purpose of facilitating the financing of exports, the government advancing the funds and exercising its influence over the bank by the appointment of directors. An export credit insurance fund was also created from which the government received half of the premiums, but in turn bore half of the ordinary and all of the extraordinary claims for damages.

Permanent Export Vigilance Committee.—By royal decree of August 25, 1928, the so-called "Permanent Export Vigilance Committee" was established in Spain. The committee carries on the marketing investigations, supervises grading and classification, and creates national trade-marks. It is entitled to impose fines for low quality and unauthorized use of the trade-mark. The use of trade-marks is not compulsory, but they cannot be used if the product does not correspond to certain standards. A special fruit-export investigation committee was formed by royal order of June 18, 1930. This committee deals mainly with aspects of fruit marketing abroad. Neither of these two committees, however, is expected to accomplish anything of outstanding economic importance for the Spanish raisin industry.

RELATION OF THE GOVERNMENT TO THE JUNTA AND THE CAMARA

On the whole, there seems to be a lack of national policy in Spain as far as the raisin industry is concerned. Two organizations, the Junta[72] and the Camara,[73] have been instrumental in accomplishing some good for the raisin industry but neither of these was organized, maintained,

[72] Locally known as the "Junta Provincial de Defensa contra la Falsificacion de la Pasa Moscatel de Málaga."

[73] Locally called the "Camara Oficial Pasera de Levante."

or aided financially by the government. The Camara, otherwise known as the Official Raisin Chamber of the Levant, in Denia (Alicante), is no longer in operation. The Junta, or the Muscatel Raisin Defense Council of Málaga operated until January 11, 1933, when it was replaced by the Málaga Muscatel Raisin Committee. The original plans for these organizations, as well as later changes, were initiated by the raisin industries at Málaga and Valencia-Alicante. The only part the government played in connection with the activities of these two organizations was to authorize their existence and approve changes in their regulations from time to time. For this reason, one cannot call the establishment of these organizations direct government assistance. Government officials, however, have served on the governing committees of both organizations, partly as a matter of policy so as to have a neutral member present, but they have also directed their activity along the lines of the economic policy adopted by the government, particularly in recent years.

The Junta at Málaga extended its activity only to the Muscat raisin industry of Málaga while the Camara dealt exclusively with raisins of the Valencia-Alicante district. During the time when the Camara was in existence, there was no collaboration between the two organizations. This, however, is not to be considered unusual since the two industries in Málaga and Valencia-Alicante face entirely different marketing problems.

THE JUNTA, OR MUSCATEL RAISIN DEFENSE COUNCIL

Purpose of the Junta.—The establishment of the Junta, i.e., the Muscatel Raisin Defense Council, was authorized by a royal order dated July 12, 1913. The object of this council was to protect the reputation of the Muscat cluster raisins of Málaga on foreign markets.[74] Growers, warehousemen, and exporters demanded its formation, because they were suffering losses in trade as a result of the practice of adulteration, engaged in by irresponsible exporters who were mixing cheaper and inferior raisins, not Muscats, with genuine Muscats of Málaga and were cutting prices in the foreign markets accordingly. Moreover, the net weight of fruit was not always as indicated on the container. The Junta, therefore, was authorized to issue regulations covering compulsory standards for grades and weight, which, of course, were also intended to improve the quality of the pack and to strengthen the reputation of the Málaga product. This control feature is exercised by inspectors who

[74] It is interesting to note that some of the functions of the Junta are similar to those of the Dried Fruit Association of California and the Dried Fruit Export Association of California, although the Junta differs considerably from these California organizations in a number of respects.

examine as many containers of each shipment as deemed necessary. The Junta has the right to confiscate fruit that is not packed in accordance with the regulations, and to assess fines. The expenses for the work done by the Junta are covered by a levy per container exported.

In the course of the years, many changes have been made in the grade regulations and other characteristics of the Junta,[75] but the principle of its activity has remained the same since 1913. A royal order of August 21, 1930, provided that the membership of the Junta would be renewed annually by the election of four raisin growers and four exporters. In addition to these, the Junta has two government officials for president and secretary. The president is the Chief Agricultural Engineer of the State Service of Agronomy, in the Province of Málaga. Two members of the Junta, together with the two government officials, constitute a Permanent Committee, which enforces the standards and regulations issued by the Junta and supervises the work of the corps of expert examiners. The levy to cover the operating expenses of the Junta amounts to 7 Spanish cents[76] for each case of 10 kilograms exported. Of the 7 cents received, 3 cents go to the examiners, 3 are used to advertise Málaga raisins, and 1 cent is returned for the general expenses of the Junta.

Export Regulations and Control Under the Junta.—In order to secure permission to store and pack raisins, every raisin exporter in the Málaga district of Spain must be inscribed in a register kept by the Ministry of National Economy. Also, before August 31 of each year, exporters, warehousemen, and middlemen had to make known to the Junta the locality of their packing houses; thus inspection of the packing sheds was made possible. Exporters must also indicate to the Junta their trade-marks. Containers must bear the register number of the exporter, the variety of raisin, and its quality within the standard types. If fruit from a preceding crop was exported during the new season, containers must have a label indicating the old crop year with the words, "Crop of the year ....." Only one variety of fruit was allowed to a container. Clusters must not be mixed with loose raisins of the same grade. A printed label inside the container must indicate the standard and must be printed in three languages and bear, in addition, the signature or seal of the President of the Junta.

The inspection of packed fruit ready for shipment takes place on the dock or on the railroad. As a general rule the fruit must be sound, suffi-

[75] See: Gaceta de Madrid: Royal orders of September 18, 1914; April 12, 1920; July 28, 1925; July 19, 1926; June 9, 1927; June 1, 1928.

[76] In January, 1930, this would have been equal to about 9/10 cent in United States currency; in January, 1931, about 7/10 cent.

ciently dried, and ripe. The term "Pasas moscateles de Málaga" (Muscat of Málaga) can be applied only to raisins actually produced in, and exported from, Málaga.

Price-Fixing Under the Junta.—The Junta is also authorized to fix prices for the different classes of Muscat raisins whenever it deems such procedure necessary. This provision was also included in former amendments pertaining to the functions of the Junta, and actual price-fixing took place in 1926–27 and 1929–30. A royal order of July 19, 1926, empowered the Junta for the first time to fix the export prices of Muscat raisins. The bulk of Málaga clusters is sold for Christmas consumption so that price regulation is more essential at the opening of the export season because heavy shipments are normally made in September. During the several years preceding 1926, prices had opened at relatively high levels only to drop immediately after the close of the demand for raisins for the holiday trade in the United Kingdom, the United States, and Australia. This price-fixing authority was expected to prevent such wide fluctuations in the foreign market.

Prior to 1926 Málaga exporters were allowed to ship on consignment. As a result, unsold stocks accumulated in London, the chief market, year after year, which tended to depress prices. Málaga exporters who were attempting to hold up the price, which, in the case of cluster raisins, can be done readily, found themselves undersold by a number of other Málaga exporters, who tried to get rid of their consignment stocks. Since 1925, consignment sales have been forbidden and the Junta has fixed a minimum price, which was determined by a special committee and which varied according to the grade of the fruit. This committee consisted of one producer, one merchant, and a member of the Junta.

In order to avoid selling under the minimum price a special corps of officials known as *reconocedores* (inspectors) was formed. These men served as compulsory representatives through whom the exporters had to make all of their purchases from packers or growers. The *reconocedores* received as fee for their work 2 per cent of the price paid. This arrangement naturally made them interested in buying at as high a price as possible.

Middlemen or brokers who operated packing sheds were not allowed to export on their own account. They were acting, so to speak, as representatives of the growers in selling to the *reconocedores*. They received a commission, fixed by the Junta, amounting to 4 per cent of the value of raisins sold. The rest of the sales price went to the grower, who, to some extent, became protected against exploitation. The grower had to give the broker or middleman an additional fee amounting to about 8 cents a

box as storage and fire insurance. These brokers as well as producers selling directly to the exporters through the *reconocedores* were obliged to give daily public notice of their transactions as to quantity and price. The Junta had the right to inspect the books of these men in order to assure that prices paid were not lower than the minimum price established. Packers or brokers were not allowed to hold stocks with speculative motives.

The minimum prices were changed every fortnight, or whenever a change was deemed necessary. At the end of 1926, the control of prices was suspended in order to give exporters every opportunity of disposing of stocks on hand.

Effect of Price-fixing in 1926 and 1927 Seasons.—The Junta was able to sustain prices for cluster raisins during the 1926–27 season by the measures above described. There were a number of factors that caused the export demand for Málaga raisins to fall off materially during 1926–27. Ordinarily this would have caused a great hardship to growers. The maintenance of fixed prices, however, made it possible for growers to realize a fairly good return in spite of reduced exports. Among the factors causing the reduction in exports that season were the following: (1) a shortage of large-sized clusters; (2) the low exchange value of the French franc (France is the second most important customer); (3) the British coal strike; and (4) the advance in the exchange value of the Spanish peseta.[77]

The price-fixing activities of the Junta were vigorously objected to at the beginning of the season by the Association of Raisin Exporters, which has practically a monopoly of the cluster-raisin crop of Málaga. This Association also objected to the regulations issued by the Junta for the classification of clusters, saying that the preparation of the fruit in accordance with the regulations increased their cost by almost 100 per cent because only about half the quantities could be packed in one day. Some exporters, however, were in favor of continuing the price-fixing plan during the 1927–28 season. As the Spanish peseta at the beginning of the 1927–28 season continued at its comparatively high value,[78] there was recognition on the part of these exporters, at least, of the danger that a race in low-price quoting would begin in order to overcome the high value of the currency and to capture the early market.

The entire scheme remained in force unaltered for the 1927–28 season until December 15, 1927, when the market was again made free in an

[77] The peseta averaged 14.15 cents U. S. currency during January, 1926; in July it averaged 15.72 cents; in January, 1927, it averaged 16.05 cents and in April, 1927, the average was 17.64 cents.

[78] The equivalent of 17.09 cents in United States currency.

effort to move stocks. Toward the end of the season, however, there was an unusually large carryover, amounting to about 8,800,000 pounds. The price-fixing system and the regulation that the raisins had to be purchased through certain channels were blamed for this carryover. The various viewpoints regarding the matter were expressed in a general meeting of growers, brokers, packers, and exporters held about the middle of May, 1928. The majority pleaded for a return to the free market and for keeping the fixed classification of grades only, in order to prevent raisins other than Muscats from being labeled Muscatels, and to assure that the fruit shipped would be free from defective and improperly cured raisins and from mixed varieties.

Discontinuance of Price-fixing in 1928 Season.—As a result of these objections, the price-fixing scheme was abolished. The standards, however, remained in force as well as the prohibition against consignments. The latter feature was continued under a somewhat more severe form, e.g., the shipping applications were to be made in the form of sworn statements. Moreover, in order to give the work of the Junta a more official flavor the Civil Governor of the Province of Málaga was made President.

Even though official price-fixing was not continued, it is evident that the interests concerned derived some benefit from it. At any rate, the Executive Committee of the Raisin Exporters Association and representatives of the warehousemen or brokers got together and agreed upon unofficial opening prices for the 1928–29 season. These unofficial prices did not oblige either producers or exporters to abide by them but they are said to have formed a basis for opening export quotations. The opening prices were somewhat lower than the official opening prices of the two preceding seasons, and were fairly well maintained until the middle of November, up to which time over 75 per cent of the total production was sold. Moreover, the Málaga exporters of raisins to South America were in a special agreement during the entire 1928–29 season for the maintenance of price levels in order to eliminate the usual rate-cutting on shipments to those markets. Efforts to bring about similar agreements among exporters to the United Kingdom and French markets were unsuccessful.

Price-fixing Under the Spanish Raisin Pool, 1929 Season.—The government authorized the Junta to resume its price-fixing and regulatory functions during the 1929–30 season. Exporters had claimed that returns under the free market were more satisfactory than during the period of official price-fixing. But the growers claimed that they had been unfairly treated by exporters and demanded a return to fixed

prices and control during the 1929–30 season. During 1929–30 the local minimum prices for the various grades were fixed by the unions of agricultural coöperatives engaged in raisin growing. They had to communicate these prices to the Junta for approval. If the Junta disagreed with the prices, the Ministry of National Economy gave the final decision. Authority was provided for modifying the prices from time to time during the course of the season, according to stocks and export demand. The initiative for such modifications devolved upon the Permanent Committee of the Junta in coöperation with the unions, the warehousemen, packers or brokers, and the exporter association.

As in the preceding years, the brokers and warehousemen were not permitted to trade in raisins for their own account. A new system of controlling transactions was followed during the season. The warehousemen had to keep two stub books, one for entries and the other for withdrawals. Each book had three stub sections; one was kept by the warehouseman, one was given to the grower, and the third was handed over to the Junta. All particulars regarding each transaction were mentioned on these stubs, including the price. The warehousers, moreover, had to form from their own group a Vigilance Committee of three which had to inspect the warehouses and examine the stub books.

The procedure actually followed in marketing the 1929–30 crop was tantamount to a monopoly. The *reconocedores,* or inspectors, resumed their activity under the direction of the Civil Governor of the Province of Málaga. In addition to controlling all transactions by the *reconocedores* system and prescribing a minimum price to be paid to growers, the Junta also fixed the minimum prices for the sale of Málaga Muscat raisins in foreign and Spanish markets.

Since the various markets offer different characteristics as regards trade practices and prices, the export market was divided into nine groups,[79] while Spain formed the tenth. The shippers had to join these groups according to the market catered to. The members of each group made special rules under which to carry on the trade. They also agreed on prices to be charged in their market. These prices were subject to approval by the Junta. It would have been difficult for the Junta to control the transactions and prices of all individual exporters under this arrangement. This difficulty, however, was eliminated by compelling

[79] These groups were: (1) United States and Canada; (2) United Kingdom and colonies; (3) France, Belgium, Italy and possessions; (4) Germany, Austria, Czechoslovakia, the Netherlands; (5) Scandinavian countries and Finland; (6) Portugal; (7) Brazil; (8) Argentina and Uruguay; (9) Cuba, Puerto Rico, Mexico, and Central America.

all exporters to join the Málaga Raisin Exporters Association and thus form a pool or cartel.[80]

The above system remained in force for the entire 1929–30 export season. In September, 1929, the prices for each group of countries to which raisins were exported, were made uniform. Prices were maintained at a favorable level up to December although the maintenance of the high level somewhat curtailed sales. Stocks at the end of the season (March, 1930), however, were large, and as a result, prices had to be lowered considerably. Notwithstanding this fact, the greater part of the crop realized higher prices than market conditions appeared to justify, and on the whole, the price-fixing mechanism is said to have worked fairly well.

A royal order dated August 21, 1930, restored complete liberty of trade to the Málaga Muscat raisin industry. This order, however, did not abolish the Junta, but left as its functions the control over grade, quality, and weight. However, the 1930 order gave the Junta the right to resume its price-fixing and trade-control activities whenever such action was deemed necessary.

MÁLAGA MUSCATEL RAISIN COMMITTEE, 1933[81]

By a government decree of January 11, 1933, the Junta was dissolved and its functions, patrimony, and obligations transferred in their entirety to the "Málaga Muscatel Raisin Committee." The main object of the Committee was to market the unexportable surplus of Muscats of the Málaga district in the domestic Spanish market before the 1933 raisin crop came on the market, and it was set up to function up to August 30, 1933, only. The raisin surplus was practically expropriated since all owners of raisins, growers, warehousemen, or syndicates had to consign their unsold stocks to the Committee which stored them in a special warehouse in Málaga or left them in local storehouses under strict supervision. The delivered surplus of raisins was pooled by the Committee according to grades, and growers obtained loans on them from the official agricultural credit service through the medium of the Committee

[80] The Association itself seems not to have been very much in favor of this arrangement. In its publication, *La Pasa de Málaga* of October 15, 1929, it is pointed out that in the opinion of the exporters the regulative scheme is superfluous and that the Association accepts the principle of a compulsory pool only as a "necessary evil," because there is no sincere and spontaneous coöperation among exporters.

[81] Greater detail regarding the organization and functions of this Committee will be found in a statement prepared by the author for the Office of the U. S. Agricultural Commissioner at Marseilles, France, under date of January 21, 1933, and issued as a four-page mimeograph release on Málaga raisin surplus to be marketed under compulsory pool scheme by the Federal-State Market News Service, Sacramento, California. February 6, 1933.

as soon as delivered. The Committee was directed to sell the surplus to any one who wished to buy raisins at minimum prices fixed by it from time to time and was to organize a campaign to increase domestic sales in Spain. Any unsold stocks on hand August 30, 1933, were to be used for wine-making.

THE CAMARA, OR OFFICIAL RAISIN CHAMBER OF THE LEVANT

The Camara, or Official Raisin Chamber of the Levant, was formed in 1927 to organize and regulate the raisin trade of the Valencia-Alicante district. The Valencia-Alicante raisin trade, which centers mainly in the city of Denia, was not interfered with by the government up to 1927. The main difficulty of the Valencia-Alicante industry was to obtain remunerative prices. Although an organization known as the Raisin Owners Association (Sindicato de Tenedores de Pasas) coöperated to a certain extent and fixed opening prices to be quoted by its members, there was a general lack of adequate coöperation in bringing about remunerative prices. Many exporters sent large shipments to the United Kingdom on short-time credit consignments without regard to the ability of the English market to handle them. The auction prices thus became demoralized, and naturally heavy depreciation followed in the home market.

To prevent this, and to bring about concerted action between the various groups of the industry, a series of royal orders was issued, dated January 31, March 9, and July 22 in 1927 and another on September 29, 1928, which in the aggregate, gave birth to the organization known as the Camara. A detailed description of the organization and its gradual development would fill a volume and is far beyond the scope of this study. The main principle of the Camara was to unite all growers and exporters for the purpose of outlining and carrying on a uniform policy on behalf of the local raisin industry. For that reason every grower and merchant was a member of the Camara and could express his viewpoint in its regular and extraordinary sessions. The activity of the Camara, however, was directly dependent upon the approval of the Council of National Economy of the Ministry of National Economy. Any decision taken by the Camara could, therefore, easily be overruled. As the Spanish dictatorship was in power simultaneously with the existence of the Camara and as the Council of National Economy delegated a special supervisor to the Camara, the decision of the actual grower members did not have much significance.

Administrative Organization and Financing of the Camara.—The Camara was administered by two committees which worked under the

direct supervision of the Council of National Economy. The first committee was the Committee of Direction, which outlined the policy to be followed and was presided over by the Civil Governor of the Province of Alicante. This Committee consisted of a grower majority elected by the growers (nine to twelve growers at least), three individuals with experience in the raisin trade, appointed by the government, the President of the Federation of Agricultural Syndicates, the Director of Customs in Denia, the above-mentioned special supervisor from the Council of National Economy, and a representative of the provincial section of the Council of National Economy.

The task of putting the recommendations of the Committee into effect was delegated to the second committee, known as the Executive Committee. This Committee consisted of two growers, elected by the above-mentioned Committee of Direction, and had as its president the President of the Federation of Syndicates. Other members were the representative of the provincial section of the Council of National Economy, the special supervisor (already mentioned), and three experienced traders appointed by the government. The Secretary General of the Camara was *ipso facto*, a nonvoting member of both of these committees.

The object of describing this complicated organization in such detail is to show first, that the exporters were scarcely represented since they had no one elected from their own group[82] on the committees, and secondly, that speedy action could hardly be expected from an organization which had so much committee work, and finally, that the government reserved the main influence for itself.

A royal order of August 2, 1929, entrusted the management of the Camara entirely to the Executive Committee, which was reformed. One can say that during the whole period of the Camara's existence changes were continually under way. The new committee consisted of a president appointed by the government, the Chief of Customs, the Agricultural Engineer, the President of the local Federation of Agricultural Syndicates, and a notary. The significant feature of this Committee was that it contained no producers or exporters.

The Camara was financed by a levy on all raisins produced. This levy was assessed yearly by the Committee of Direction, which based its decisions in the matter on the data received by means of an annual census of the raisin acreage and production.[83] Twenty-five per cent of this income was supposed to be spent for propaganda purposes.

[82] The government held the rather outspoken view that the growers were more interested in the Camara than were the exporters.

[83] The results of this census have never been made available.

Functions of the Camara.—The Camara was originally intended to be a permanent institution, occupied with rationalization of raisin growing and organization of marketing; actually it established compulsory grades and had some influence on transportation charges, export duties, and local taxes. Its inspectors were supposed to supervise the industry vineyards as well as packing establishments, to make soil analyses, advise and direct in methods of cultivation and drying, etc. There was also a provision for the formation of a credit branch of the Camara, which, however, never came into activity. Successful marketing was to be brought about by the establishment of branch offices in an indefinite number of markets, but the London office was the only one ever opened.

Fixing of Minimum Prices.—In order to bring about orderly marketing, the Camara was authorized to fix the minimum price at which dealers could buy from producers and the minimum price at which they could sell. These prices were to be based on the cost of production, world market prices, and demand from all markets. The quantity of raisins which could be shipped on consignment within a certain period was also fixed, as well as the grades which could be exported. In the second year of its existence the Camara allotted to each exporter a fixed amount which he could ship during the season to the various markets. The daily maximum to be exported by the individual shipper was also fixed. It is claimed, however, that this allotment was not based entirely on the amount of business usually accomplished by each exporter. As a result it created much ill feeling locally, although it did help marketing in the United Kingdom to a certain extent.

In the exercise of its price-control policy, the Camara required growers, dealers, and exporters to submit documents covering each transaction to show that the prices involved were not below its fixed minimum. This particular feature, however, constituted the weakest link in the Camara's activities. Even during the first season of its existence some exporters sold below the fixed price, despite their signed statement to the contrary. The Camara was severely criticized by exporters who complied with the regulations. The practice, however, was handled with great lassitude, so that eventually practically every one handed in the statements but sold at the price of their own choice. Furthermore, when prices in London were good, the Camara permitted more to be sent on consignment than the regulations permitted. This caused British buyers to have little faith in the Camara.

In addition to all of the above-mentioned hindrances and disadvantages, the expenses of the Camara were excessive in view of the small size of the industry and the low prices prevailing. Moreover, since this

organization was an institution of the dictatorship, it was abolished by the new government on March 15, 1930. The Valencia-Alicante raisin industry unquestionably needs some kind of an organization to help secure unified action in solving its problems, particularly under present competitive conditions and in view of the shift to seedless varieties. It is possible, therefore, that sooner or later a new organization may be created, although nothing is known about plans to this effect at the present time.

THE PERSIAN RAISIN INDUSTRY[84]

The raisins produced in Persia are mostly seedless varieties resembling the Turkish sultana. The best kind of raisin produced, known as *sabsa,* can be sun-dried in only three days. It is usually dipped in a boiling solution containing sodium carbonate, before drying. The output of this kind is almost entirely exported. The *bedana,* the second best kind of raisin grown in Persia, is consumed almost entirely in Persia. A third kind, the *askari,* is used chiefly in wine production.

The growers dry their raisins on the bare ground or on blankets and then carry them to the villages and principal centers, where they are sold to small traders or brokers. These in turn arrange for transportation to exporting merchants, who are to some extent financed by foreign importers.

PRODUCTION TREND

No complete census has ever been made of agricultural production in Persia nor has there ever been issued an official estimate of raisin production. Estimates from unofficial sources, however, shown in table 35, have been submitted by American Consular officials. These rough production estimates, together with the export data in the same table, show the trend in production in the last twenty years and give an approxi-

[84] Based in part on information supplied by Mr. Earl S. Haskell, former Director General of Agriculture in Persia.

General sources used for this section in addition to those given in specific footnotes:

Arnois, Herbert. Persian and Russian raisins on the German markets. California Fruit News 83 (2239). June 6, 1931.

Fisher, C. B. The feudal system in Persia. Jour. Farm Econ. 13:621–629. 1931.

Knight, Jewell B. The existing state of Persian agriculture; opportunities for improvement, etc. League of Nations. 1926 (Mimeo.).

League of Nations. Commission d'enquête sur la production de l'opium en Perse. Rapport au conseil. 61 p. Imp. Réumes. Chambery. 1927. (Publication de la Société des nations. XI. Opium et autres drogues nuisibles. 1926. XI. 10.)

Millspaugh, Arthur Chester. The financial and economic situation of Persia. 37 p. Published by the Imperial Persian government and distributed under the auspices of the Persia Society. 1926.

[Persia.] Administrator-general of the finances, quarterly reports. Teheran.

mation of the relative changes in commercial output from year to year since the World War. They indicate that Persia is not only a strong competitor with Turkey in the production of raisins but that she is probably the second largest raisin producer in the world after the United States. Both the trade estimates of Persian raisin production and the

TABLE 35

Exports of Raisins from Persia and Unofficial Production Estimates, Average 1909–1913, Annual 1921–1931

Year*	Production*	Exports*
	short tons	*short tons*
Averages:		
1909-1913	55,000	32,960†
1921-1925	44,800	19,961
1926-1930	42,980	19,563
Annual:		
1921	35,000	5,965
1922	45,000	11,088
1923	49,000	21,304
1924	55,000	30,774
1925	40,000	30,672
1926	44,000	14,458
1927	49,000	26,226
1928	49,000	21,876
1929	37,000	17,881
1930	36,300	17,374
1931	38,500	29,139

* Production data are for crop years; export data are for years beginning March 22. See text (page 86) for Nielsen's revised estimates of production for 1929–1932.

† Average for the years 1911–1913.

Sources of data:

Data on production are unofficial estimates.

Data on exports 1911–1913: from the Internatl. Yearbook of Agricultural Statis., 1924–25, table 121, p. 265. Data for 1921–1931: are derived from official Persian sources.

export data in table 35 agree in showing that post-war average supplies of Persian raisins have been about 12,000 tons less than the pre-war average. The annual data from 1921 to 1931 show no decisive trend in production.

These trade estimates of production are probably relatively, but not absolutely, correct. Revised estimates of Persian raisin production recently made by Nielsen[85] for the years 1929–1931 indicate that the old trade estimates for these years are too high.

On the basis of the official export data, for years beginning March 22, and estimated Persian consumption at home of about 10,000 tons of

[85] Nielsen, N. I. U. S. Agricultural Commissioner, Marseilles, France. Preliminary Report on the 1932–33 raisin and currant season of the Mediterranean basin. Federal-State Market News Service. Foreign Raisin Report No. 39:16–17. March, 1933. (Mimeo.) Sacramento, California.

raisins, Nielsen has estimated total Persian production for recent years at 28,000 tons in 1929 and in 1930, 48,000 tons in 1931, 15,000 tons in 1932, and possibly 30,000 tons in 1933. Revised estimates of Persian raisin production comparable to those of Nielsen for 1929–1932 are not available for years prior to 1929. Since these export statistics do not give shipments to foreign countries by crop years, they do not show the exact changes in exports from individual crops.[86] However, they show rather accurately what the trend in exports has been. If consumption of raisins in Persia has been fairly constant at about 10,000 tons, the figure used for recent years, the trend of production can easily be visualized by this addition to the export data in table 35. The export data alone are the best indication available of the trend of the competitive commercial output. Nielsen's revised data show average production of about 30,000 tons of raisins for the four years 1929–1932 while exports in recent years have averaged around 20,000 tons.

The Persian raisin industry experienced a temporary setback because of war disturbances but it has been recovering steadily during the past decade. Raisins are an important item in the daily diet of the Persians as well as an export commodity. Because of the relatively high value of raisins in proportion to their weight they have been able to overcome, to some extent, the handicap of the inadequate and costly transportation service of Persia and have therefore been one of the most important agricultural exports of the country. An average of nearly 21,000 tons were exported annually during the four years 1927 to 1930.

MARKET OUTLETS

Until 1930 the Persian raisin industry was almost entirely dependent upon the Russian market, which took about 95 per cent of the exports (table 36). The rest of the exports were distributed mainly to British India, Iraq, and small amounts to Turkey. One often encounters the statement that Persian raisins have competed very little with other

[86] In years of abnormally large crops preceded and followed by normal or smaller crops, the official export data as given for fiscal years beginning March 22 are probably considerably smaller than actual exports from such large crops. The reasoning involved in this conclusion is well illustrated by data on the 1931 crop-marketing season. Production in both 1929 and 1930 was about normal and exports for years beginning March 22 were about the same. Therefore, exports for the five months after March 22, 1930, were probably about normal for that period of the marketing season. However, in the official statistics for the year beginning March 22, 1931, the normal exports of this five-month period would be added to the raisin exports from the large 1931 crop up to March 21, 1932. However, exports from the large 1931 crop after March 22, 1932, are known to have been abnormally large, amounting to 11,844 tons for the period March 22 through July 21, 1932. Exports for the fiscal year March 22, 1931, to March 21, 1932, were, therefore, in all probability considerably smaller than the total tonnage actually exported from the large 1931 crop by the fall of 1932.

raisins in international trade, but this is only partially true for Russia and the other countries consuming Persian raisins would probably have imported raisins from other countries had it not been for the Persian product. Direct competition from Persian raisins, in markets outside Russia, was first experienced during the 1930–31 marketing season. Table 36 shows the big decrease in exports to Russia in that year and the

TABLE 36

RAISIN EXPORTS FROM PERSIA BY COUNTRIES OF DESTINATION, 1926–1931

(Year beginning March 22)

Destination	1926	1927	1928	1929	1930	1931
	short tons	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*
Russia	12,630	24,986	20,562	16,036	4,527	5,377
British India	1,088	861	845	887	1,283	1,486
Iraq	439	268	366	385	463	597
Germany	2	4	9	178	10,344	20,045
Turkey	175	42	16	340	176	89
Great Britain	1	*	10	6	188	629
Netherlands	*	*	*	*	152	72
Italy	*	*	*	0	120	604
France	*	*	*	16	89	49
Other countries	123	65	68	33	32	191
Total	14,458†	26,226	21,876	17,881	17,374	29,139

* If any, included in "other countries."

† Exports in 1926–27 were materially reduced because of the Russian embargo on Persian raisins during 1927.

Source of data:

Compiled from official Persian sources by U. S. Agricultural Commissioner, N. I. Nielsen, Marseilles, France. (See: Federal-State Market News Service, Foreign Raisin Reports [Mimeo.] Sacramento, California.)

increase in exports to European countries in which California raisins are marketed. In 1930–31, for the first time, direct exports to Germany became important, amounting to over 10,300 tons, or nearly 60 per cent of total Persian exports. A considerable part of the exports to Germany, however, probably represent shipments to Hamburg for reshipment to other countries.

Problem of Improving Quality.—Although Persian grapes are of excellent quality, the raisins made from them are generally inferior in quality on account of careless drying and processing by the grower and poor packing and possibly some adulteration after the raisins leave his hands. The government has not interfered with these practices, although it is recognized that the fruit would bring much more money if modern methods of drying and preparing for market were adopted. It should be remembered, too, that the raisins for export have, for the most part, been cured to meet the peculiar demands of the Russian markets, which

require a special preparation, generally sour, mixed with various seasonings, etc. Raisins so cured are unpalatable to other than Russian tastes and are generally unmarketable elsewhere. The Russian market has been catered to for so long a time that the Persian growers do not understand how to cure and handle for other markets. Probably the most important factor in extending the market into countries other than Russia is improvement in present methods of processing and packing.

According to Nielsen[87] it appears that an improvement in the quality of Persian raisins may reasonably be expected in the future. If proper drying and packing methods are employed, he states that the dipped Persian raisins could be brought up to a quality comparable with Smyrna sultanas and the Bidonas to a standard similar to the California natural Thompson Seedless raisin. Reliable information indicates that some improvement along this line has taken place in 1931 and 1932. Interests outside of Persia are reported to be pushing such improvements, which seems to be true since a few samples of dipped Persian raisins seen from the 1932 crop have compared very favorably with Smyrna raisins. Other samples seen were of dipped, unbleached raisins similar both in quality and color to the small and medium-sized Greek sultana raisins.

GOVERNMENT AID

The Persian raisin industry spreads over all the high table land of the interior, the three principal zones being Azerbaijan in the northwest, Shiraz in the south, and Khurasan in the northeast. The industry has developed into its present dimensions on the basis of natural economic equilibrium, for the government has not taken any special measures on behalf of raisin growing, although other industries have received considerable attention and in several instances financial support, particularly in the case of cotton, tea, and silk. For that reason, such stimulus as the industry may have received as a result of government action must be sought in legislation providing for the improvement of agriculture as a whole.

Taxation.—For many years the absence of a strong central government and the semi-independence of tribes and of entire regions retarded the development of agriculture and trade in Persia. After the revolution of 1921, however, conditions changed and it can be said that at present the economic situation of the country is fundamentally sound. Government finances have been reorganized since then and the complicated and

[87] Nielsen, N. I. U. S. Agricultural Commissioner, Marseilles, France. Preliminary report on raisin and currants in the Mediterranean basin, 1932–33 season. Federal-State Market News Service. Foreign Raisin Report No. 39:16. March, 1933. (Mimeo.) Sacramento, California.

burdensome taxation system revised so that "tax-farming" has been abolished and taxes have been reduced from 10 per cent to 3 per cent of farm incomes. Abolition of the old system of subletting the collection of taxes has been an essential step toward agricultural development, for peasants no longer need to fear that improvements will only increase the tax collector's receipts.

Rural Credit.—Under the dominant system of large landed proprietors most of the peasants are merely laborers, uneducated and living in relative poverty. Agricultural improvements, such as coöperative financing and marketing, have been difficult because of the selfish interests of the proprietor and the ignorance of the peasants. Under the landlord system loans in kind are made to the peasant at interest rates from 12 to 30 per cent. The small holders' operations, which are mainly in garden and vineyard cultivation, are usually financed by the village broker, which is frequently an unsatisfactory state of affairs and raises a serious obstacle to the development of an improved raisin-marketing system.

The establishment of a State Agricultural Bank has been contemplated by the government, since the banks now operating in Persia confine themselves purely to the banking business and trade financing and are not allowed to make loans on farm lands. The National Bank, founded in 1927, with a small capital supplied by the government, was originally intended to encourage agriculture as well as industry and trade, but has not done so. It was recently proposed to add $5,000,000 to the capital of this bank for loans to assist agricultural development, but as yet it has very little capital. Undoubtedly the establishment of an efficient rural credit system, particularly for small holders, would greatly benefit the Persian raisin industry.

Agricultural Education.—Of all the important raisin-producing countries of the world, agricultural conditions in Persia are said to be the most backward. The most primitive methods of irrigation, culture, and processing of farm products are still in vogue. The Persian peasant is said to be intelligent, but a system of agricultural education is only in its infancy. In 1923 the government established an agricultural school at Teheran with the intention of sending the students trained there into the different parts of the country for extension work. The school also arranged agricultural exhibits, especially displays on the use of agricultural machinery. This machinery is also used on the state farms.[88] Up to the present, only one of the model farms attached to the agricultural school has an experimental vineyard. The government also sends out a

[88] Fatch, Moustafa, Khan. The economic position of Persia. 98 p. P. S. King and Son, Ltd., London. 1926.

number of students to study cultivation methods abroad. One of these has studied raisin-grape growing and manufacturing in California and is planning to introduce improvements in Persia.

Irrigation.—Rainfall in the raisin-growing regions of Persia averages only 2 to 15 inches so that irrigation of vineyards is the usual practice. The methods, however, are primitive, although it is said that an unusually large portion of available water is effectively utilized for irrigation, in spite of the fact that there are very few dams for impounding spring flood waters. It seems unlikely that the government will undertake a program of irrigation development in Persia. For one thing, the expense involved would probably be prohibitive, since much of the construction material and equipment would have to be imported and transportation into the interior would be very expensive. Even though water is the limiting factor to agricultural expansion in Persia and modern irrigation construction is unlikely, available information indicates that with improved methods of processing, marketing, and transportation, Persia might easily be induced to double her present raisin output.

Transportation.—The prevailing inadequacy of transportation facilities is one of the most important items hindering the development of the raisin industry. Persia is situated very favorably at almost equal sea-travel distance to eastern and western markets, besides having a very good outlet in Soviet Russia for her fruit. The trade with Russia is handled mostly through the Caspian Sea ports, particularly Pevahli. Other accommodations for shipping overseas are very poor indeed. Russia has established a service between Odessa and Bushire in the Persian Gulf, via Suez. A British and a German line also have regular service to Bushire. The government intends to build an entirely new port at Bandar Shapur, which is to be the southern terminus of the projected North-South railroad. This railroad, part of which has already been constructed by American and German interests, will run from the Caspian Sea to the Persian Gulf. When completed it will be of the utmost importance to the raisin-growing regions located in the northwest and northeast of the country, particularly for shipping fruit to India and the Far East. The total length of the railroad will be 963 miles. This will mean a land transportation period of only 5 to 10 days as compared with the present 30 to 40 days required by caravan. It will be many years, of course, before the railroad is completed and also before markets for Persian raisins in the thickly populated Far East will have been secured.

In the meantime, road construction will probably continue to make progress. In fact, the transportation in vogue, i.e., by caravan, on camel, or donkey's back, is vanishing rapidly. The government has been devot-

ing a fair measure of attention to road construction and as a result truck transportation is increasing. The government itself has acquired and is operating trucks. Continued development of truck transportation should help to increase the export movement of raisins by steamer from the Persian Gulf ports. Freight rates for truck transportation are declining. Five years ago a premium of about 100 per cent was charged for truck transportation over the caravan transportation rate. This premium was reduced to 20 per cent in 1927. It has practically disappeared on certain routes at the present time.

The raisin-growing district in northwest Persia has the potential advantage of being able to ship over the Northern Railroad from Julfa via Tiflis across Soviet territory to Batum, a Russian Black Sea port. Hence raisins from this district have convenient access to the markets of Rumania and southeastern Europe. According to a commercial agreement (October 1, 1927) between Soviet Russia and Persia, exports from Persia may be shipped through Russia without a special license and limitation. This agreement also authorizes the use of the Caspian Sea for shipping fruit from a Persian port to Baku, transporting it thence by rail to Batum.

FUTURE PROSPECTS

From the preceding discussion one may justly conclude that prospects for the long-time improvement in the Persian raisin industry seem bright. When the Persian government decides to give special attention to the raisin industry, by improving sanitary conditions (and it will eventually do so because the dried-fruit item is important in the trade balance), a demand for Persian fruit will undoubtedly arise in countries, which up to the present have not taken the Persian product because of the availability of cleaner and better raisins from other sources. The big increase in exports to Germany since 1929 seems to be in line with such a development.

The potential foreign markets for Persian raisins are especially interested in the development of the Persian raisin trade because of the reciprocal trade relations that might grow out of such an arrangement, particularly the possibility of expanding outlets for manufactured goods without encountering the obstacle of prohibitive tariffs.

The potential increase in the productiveness of existing Persian vineyards and also of new vineyards is difficult to gauge. Little is known about yield per acre, cost of production, or the probable acreage suitable and available for raisin production. However, it is said that over a period of years Persia could double her raisin output. Nielsen states that no definite data on the trend of raisin-grape acreage in Persia are avail-

able, but that statements have been made to the effect that in 1924, 1925, and 1926 plantings were rather extensive, but whether or not much has been planted since then is not known. His estimates of production for the four years 1929–1932 average 32,000 tons. The production of 1931, 48,000 tons, however, is sufficient evidence that in favorable years Persia can produce and export large quantities of raisins. If the Persian industry can continue to exist in spite of its handicaps and Russia does not again absorb a large majority of its raisins, other producing countries can expect continued competition from Persian raisins in European markets, particularly as the quality of the exported pack is improved.

THE RUSSIAN RAISIN INDUSTRY[89, 90]

Grapes are grown in many parts of Russia but raisins are produced on a commercial scale only in Russian Turkestan, the territory lying just north of Persia and Afghanistan and stretching 1,200 or 1,300 miles east of the Caspian Sea. The greater part of the western two-thirds of this territory is desert but in eastern Turkestan are numerous large valleys in which crop production on an extensive scale is made possible by irrigation from the rivers which have their source in the neighboring snow-capped mountains. The arid climate of Turkestan with hot, dry summers and autumns and relatively cold but short winters is well adapted to the production of cotton, rice, and dried fruits under irrigation, which natural tendency the Soviet government is assisting.

Drying of fruit on a commercial scale in Turkestan has naturally resulted from climatic conditions similar to those in the San Joaquin Valley favorable to fruit growing under irrigation and to sun-drying the fruit after harvesting, together with the fact that it has always been

[89] General sources used for this section in addition to those given in specific footnotes:

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Russian Ministry of Agriculture. A sketch of the condition of arboriculture, gardening and viticulture in Russia. 1914.

Shitt, P., and I. Soklow. On the new roads—results of the new economic policy.

[90] This chapter on the Russian Raisin Industry was written by S. W. Shear, Associate Agricultural Economist in the Experiment Station and Associate Agricultural Economist on the Giannini Foundation, largely on the basis of translated Russian literature. Acknowledgments are due to Dr. Lazar Volin of the Foreign Agricultural Service Division of the United States Department of Agriculture, Bureau of Agricultural Economics, and Mr. B. Kaplan, student translator, for searching and translating the Russian literature. The following persons were generous in giving information based upon their observations while traveling in Russian Turkestan: Messrs. F. J. Mulligan, A. P. Davis, G. H. Carr, L. D. Wilbur, and Professor W. W. Mackie. Mr. Mulligan spent the year 1929 in Uzbekistan supervising the installation of raisin and dried-fruit processing and packing machinery in two plants erected for that purpose by the Soviet government.

difficult and costly to transport fresh fruit to the distant consuming markets of Russia. Gradual improvement in refrigerator-car service has been taking place in recent years, but still the long haul must remain expensive. Raisins, apricots, and cherries are the chief dried fruits produced in large commercial quantities in Russian Turkestan. About half of the grape production is said to have been dried in recent years.

PRODUCTION AND SHIPMENTS

Kind of Raisins.—The Turkestan term for raisins is *kishmish*, whereas the Russian term is *usum*. The chief raisin varieties grown in Turkestan and the chief types of raisins produced are the same as those in Persia and known by the same or similar names. In the European dried-fruit trade, therefore, frequently little or no distinction is made between raisins of Persian and of Turkestan origin, partly because of the similarity in marketing methods and the fact that in the past Persian raisins have so largely moved into Russian and other European markets via Turkestan over the same transportation routes. Jaroshewich[91] states that the chief varieties of raisin grapes grown in Turkestan are the White Kishmish or Ak-kishmish, the Black Kishmish or Kara-kishmish, the Maska or Angur-kalian, and the Muscat. The White Kishmish is the Sultanina, a white seedless grape like the California Thompson Seedless or the grape from which Turkish sultana raisins are made. A large majority of the commercial raisin output is of this variety. In the Samarkand region, where it is the most popular variety, it constitutes about 75 per cent of all vines. Several different kinds of raisins, depending upon the method of drying, are made from this variety of raisin grape.

Methods of Drying.—Three methods of drying grapes are used.[92] *Avtobi* is direct sun-drying which produces the natural (undipped) type of raisin. It is the most common method employed. The *bedana*, the best known Turkestan raisin of this type, is made from the White Kishmish grape by sun-drying for 14 to 16 days. *Soyagi* are raisins dried in the shade in special drying barns with narrow openings in the walls for circulation of air. When dried in this way, the raisins produced from the White Kishmish are green in color. *Abdjet* are raisins made by sun-

[91] Jaroshewich, N. K. Fruit and grape industry in Uzbekistan. Contribution of the Agricultural Department of Central Asia, University at Tashkent. Series 4-B Economics 2d ed. p. 327. 1929. The author is Professor of Farm Organization in the State University of Central Asia.

[92] Technical Encyclopedia 9:35–37. Moscow, 1929. [Original in Russian. Translation by Michael Shapovalov, Senior Pathologist, United States Department of Agriculture.] Also Jaroshewich, N. K. Fruit and grape industry in Uzbekistan. Contribution of the Agricultural Department of Central Asia, University at Tashkent. Series 4-B. Economics. 2d ed. p. 256. 1929.

drying after dipping the grapes in a boiling solution of potash or mixture of potash and lime. As in Persia, the raisins made in this way from the White Kishmish are commonly known as the *sabsa* raisins and are the chief kind exported.

Several less well-known types[93] of raisins are produced in Turkestan, among which are the *vassarga*, the *tsilaga*, the *guermian*, the *shigani*, and the *kara-maize*. The last two are prepared from the Black Kishmish which is a medium-sized seedless grape of a black-violet color grown chiefly in Zeravshan Province, and is similar to, if not the same as, the variety known as the Black Monnuka in California. The Angur-kalian variety, known locally in Samarkand as Maska, is a very large golden-yellow grape with a very high percentage of flesh as compared to seed. The *guermian* type of raisin is produced from this variety. The Muscat appears to be relatively unimportant in Turkestan, being grown in only two or three provinces.

Pre-War Production in Turkestan.—Prior to the establishment of the Soviet government, raisins had been produced in Russian Turkestan for many years under cultural and marketing conditions similar to those prevailing in neighboring Persia. As early as 1902 shipments of raisins from Russian Turkestan via the Transcaspian railroad amounted to as much as 22,000 tons in a year. Blagowiestschensky[94] states that during the years 1913–1915 rail movement of raisins from Russian Turkestan averaged 26,835 tons a year.[95] However, the Russian Technical Encyclopedia[96] states that nearly 33,000 tons of raisins were shipped from Turkestan annually before the World War. Part of the tonnage reported as shipped from Turkestan may have consisted of Persian raisins imported by caravan across the northern boundary of Persia. Just how much, however, is not stated in the literature available to the author. As a matter of fact, data on the quantity of Persian raisins imported by Russia and reexported are not at hand even for recent years.

Barberon[97] states that before the War Turkestan is reported to have had an annual production of about 187,000 tons of grapes of which only

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[93] Jaroshewich, N. K. Fruit and grape industry in Uzbekistan. Contribution of the Agricultural Department of Central Asia, University at Tashkent. Series 4-B. Economics. 2d ed. p. 254–256, 327. 1929.

[94] Blagowiestschensky, Georg. Die wirtschaftliche Entwicklung Turkestan. [The agricultural development of Turkestan.] Rechts- und Staatswissenschaftliche Studien 46:1–197. Emil Ebering, Berlin. 1913.

[95] Zerewitnoff, F. V. Chemistry and technology of fresh fruits and vegetables (translated title, original in Russian). p. 244. Moscow. 1930.

[96] Technical Encyclopedia 9:35–37. Moscow. 1929. [Translated title, original in Russian.]

[97] Barberon, M. G. La viticulture dans l' U. S. S. R. In extracts from: La Vie Economique des Soviets. Reproduced in: Bulletin International Du Vin 4(37): 111–112. 1931.

about 10 per cent were utilized for wine-making and the balance dried for raisins or consumed fresh. Although the fresh grapes began to be shipped from Turkestan when the Tashkent railroad was opened in 1906, fresh shipments were relatively small until after the War. Baulin[98] indicates that about 1928 or 1929 approximately 34 per cent of the normal grape production of Uzbekistan was shipped out fresh. If only about 15 per cent of the pre-war production were consumed fresh, about 150,000 tons would have been available for drying, which, at a drying ratio of 3.625 to 1, would indicate total production of about 40,000 tons of raisins. Allowing for some local consumption of raisins this rough estimate of pre-war raisin production does not seem far out of line with the available data quoted on rail shipments.

Post-War Production in Uzbekistan.—About two-thirds of the cultivated area of Turkestan is in the Socialistic Soviet Republic of Uzbek, or Uzbekistan, in which the greater part of the dried-fruit and raisin-grape acreage is located. The ancient city of Samarkand appears to be the center of the raisin industry, holding a position there similar to that of Fresno in the raisin industry of California. In the Samarkand region, as in Fresno County, the majority of the fruit acreage is in grapes and most of the grapes are raisin varieties. This one region is said to provide 90 per cent of the raisins exported.[99]

In 1929 the Technical Encyclopedia[100] states that shipments of raisins from Uzbekistan "in recent years" has averaged about 15,000 tons which agrees with data presented by Baulin[101] who states that an average of about 25,000 tons of raisins were dried in Uzbekistan in 1926 and 1928 of which about 30 per cent were taken off the market by private producers, largely for making alcohol,[102] and about 10 per cent were con-

98 Baulin, D. I. Processing of orchard, vineyard, and garden products of Uzbekistan. In: Proceedings of the First Uzbek Conference on Fruit, Grape, and Garden Culture and Apiculture. p. 92. January 16–23, 1929. Published by Peoples Commissariat for Agriculture of the Uzbek S. S. Republic, Samarkand. 1929. [Original in Russian, translated title.]

99 Berezkovskii, E. A. The vine industry of Uzbekistan. In: Journal for Reconstruction of Farming, p. 117. April, 1929. [Translated title, original in Russian.]

100 Technical Encyclopedia 9:35–37. Moscow. 1929. [Original in Russian. Translation by Michael Shapovalov, Senior Pathologist of the United States Department of Agriculture.]

101 Baulin, D. I. Processing of orchard, vineyard, and garden products of Uzbekistan. In: Proceedings of the First Uzbek Conference on Fruit, Grape, and Garden Culture and Apiculture. p. 96. January 16–23, 1929. Published by Peoples Commissariat for Agriculture of the Uzbek S. S. Republic, Samarkand, 1929. [Original in Russian, translated title.]

102 Jaroshewich, N. K. Fruit and grape industry in Uzbekistan. Contribution of the Agricultural Department of Central Asia, University at Tashkent. Series 4-B. Economics. 2d ed. p. 4–5. 1929. He states that about 13 per cent of the raisin output is utilized in the manufacture of wine and alcohol.

sumed on the home farm, and the balance of about 60 per cent were available for shipment. According to Jaroshewich, the Bureau of Plans of the Uzbek Republic reported that the Soviet government purchased nearly 15,000 tons of its raisins in 1926. About 95 per cent came from the Samarkand or closely adjoining districts. Baulin reports that government and coöperative farms produced about 7,600 tons of commercial raisins from the small crop of 1927, but does not state how many were produced on peasant farms and other private holdings. About 53 per cent of this tonnage was *sabsa* raisins and 28 per cent *bedana*.

Both Baulin and Jaroshewich state that about one-half of the grape crop of Uzbekistan has been dried in recent years. Baulin reports that 48 per cent was dried in 1928, 34 per cent consumed in fresh form, and 18 per cent used for the manufacture of wine, sirup, and alcohol. Jeroshewich[103] quotes data on the total production of grapes in Uzbekistan as 158,000 tons in 1914, 83,000 tons in 1925 (a year of unusually low yields), nearly 160,000 tons in 1926, 132,000 tons in 1927, and 210,000 tons in 1928. If one-half of the average production of 167,000 tons of grapes in the years 1926–1928 were dried, at the drying ratio of 3.625 to 1 used by Jaroshewich, the raisin output would have averaged approximately 23,000 tons for Uzbekistan alone.

FOREIGN TRADE

Imports.—In pre-war days Russia was on a substantial import basis for raisins, being second only to the United Kingdom in the quantity imported. Table 37 shows that the quantity of raisins and currants imported into Russia in the years 1909–1913 averaged about 70,000,000 pounds, very few of which were currants. About 98 per cent came from Persia, and, presumably, these were all raisins. Part of the pre-war Russian imports of raisins, however, were consumed in territory which is not now in the Soviet Union—namely, Poland, Latvia, Esthonia, and Lithuania. Of these, Latvia has been an important market for Russian dried fruit in recent years (see table 38). Russian imports of raisins and currants in recent years are shown by table 37 to have declined to only about half the pre-war average. A very large majority of these, however, are still obtained, as in pre-war days, from Persia.

Exports.—Before the War, very few raisins were normally exported from Imperial Russia and only within the last five years have exports from the Soviet Union become of importance. Exports as shown in table

[103] Jaroshewich, N. K. Fruit and grape industry in Uzbekistan. Contribution of the Agricultural Department of Central Asia, University at Tashkent. Series 4 B. Economics. 2d ed. p. 4–5. 1929.

37 probably cover reëxports of Persian raisins as well as exports of those actually dried in Turkestan. The fact that a considerable part of Persian raisins has been exported directly to European countries other than Russia in the last two years may largely account for the decline in exports of raisins from Russia in 1931 (see table 36).

Unfortunately, Russian statistics do not give exports of raisins by countries of destination separately. However, a clue to the relative importance of the chief markets importing raisins from Russia is given

TABLE 37

RUSSIAN RAISIN AND CURRANT IMPORTS AND EXPORTS, 1909–1915, 1927–1932

Calendar year	Imports of raisins and currants	Exports of raisins
	1,000 pounds	*1,000 pounds*
1909	76,909	138
1910	71,334	3,652
1911	61,674	20,586
1912	61,861	2,434
1913	78,852	295
1914	60,310	320
1915	63,049	1,133
1927*	45,501	2,829
1928*	41,978	12,103
1929*	30,825	15,267
1930	23,203	11,103
1931	5,562	5,567
1932	19,795	19,709

* Year beginning October 1.

Sources of data:
1909–1915: from Internatl. Yearbook Agr. Statis., Rome.
1927–1932: from Foreign Trade of U. S. S. R., Commissariat of Foreign and Domestic Trade.

by the data in table 38 on all Russian dried-fruit exports shipped to each of the most important markets. The fact that raisins have constituted a large majority of the total gives these data considerable significance. Moreover, they are partially supplemented by the data shown in table 39 which give the quantity of raisins imported from Russia in the last few years by a few important markets.

The German statistics, however, are for imports for consumption and do not include the quantities that may have moved via the free port of Hamburg to other countries. In the case of Persian raisins this movement is known to have been a large one in 1930–31, for official Persian trade statistics show exports of raisins to Germany of 10,344 tons in the year beginning March 22, 1930, whereas the German trade statistics report raisin imports for consumption from "other countries" of 4,370

TABLE 38

EXPORTS OF DRIED FRUITS FROM SOVIET RUSSIA BY COUNTRIES OF DESTINATION AND KINDS OF FRUIT, YEARS BEGINNING OCTOBER 1, 1927 AND 1928, CALENDAR YEARS 1929–1932

Destination	1927–28	1928–29	1929	1930	1931	1932
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Germany	1,179	4,528	5,168	3,878	3,342	15,265
Latvia	2,634	4,830	6,382	8,241	1,601	503
Great Britain	73	4,279	3,585	761	121	3,170
Netherlands	650	1,726	1,457	137	2,205	3,071
France	1,171	3,607	3,100	875	*	1,623
Esthonia	*	13	79	170	1,316	809
Norway	*	13	26	66	862	1,076
Austria	*	187	340	130	137	454
Belgium	*	183	340	*	33	926
Czechoslovakia	64	*	112	322	66	*
Mongolia	64	33	22	66	267	262
Other countries	49	211	1,107	189	262	575
Total, all dried fruits	5,884	19,610	21,718	14,835	10,212	27,734
Raisins	2,829	12,103	11,162	11,103	5,567	19,709
Apricots	2,044	5,333	8,307	2,674	3,757	6,223
Prunes	—†	1,171	1,391	577	156	201
Apples	—	37	71	141	2	11
Others	—	966	787	340	730	1,590

* If any, included in "other countries."

† Dashes indicate data not available.

Sources of data:
Compiled from Foreign Trade of U. S. S. R., Commissariat of Foreign and Domestic Trade, by the Foreign Agricultural Service of the U. S. Dept. of Agr. and the Bur. of Foreign and Dom. Com.

TABLE 39

IMPORTS OF RAISINS FROM RUSSIA INTO GERMANY, NETHERLANDS, AND THE UNITED KINGDOM, 1925–1932

Year	Germany	Netherlands*	United Kingdom
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
1925	0	9†	0
1926	0	24†	0
1927	274	30	933
1928	1,102‡	5†	896
1929	2,898‡	1,400‡	2,491
1930	2,176‡	1,024‡	3,571
1931	788‡	2,478‡	153
1932	322‡	—§	—

* Sultana raisin imports only.

† Imports from countries not specified which would include Russia if any imports were received directly from it.

‡ Years beginning September 1; calendar year used for all other data.

§ Dashes indicate data not available.

Sources of data:
Data for Germany and Netherlands compiled by U. S. Agricultural Commissioner Nielsen from official trade statistics. Current data may be found in Federal-State Market News Service, Foreign Raisin Reports. (Mimeo.) Sacramento, California. Data for United Kingdom compiled from: Annual statements of the trade of the United Kingdom with foreign countries and British possessions.

tons for the same period. The bulk of these were probably from Persia as "other countries" exclude Turkey, the United States, Greece, Russia, and Italy.

ACREAGE

In 1910 the Turkestan acreage of all kinds of grapes was nearly 17 per cent of the 509,000 acres in what now constitutes Soviet Russia.[104] By 1926 it had risen to slightly over 20 per cent of the total, then about 437,000 acres,[105] and in 1928 to about 21 per cent.

Berezkovskii[106] states that prior to the World War there were approximately 82,000 acres of grapes of all kinds in the territory now included in Uzbekistan. However, the vineyard area was reduced as a result of the War and did not expand appreciably until after 1924. According to the Soviet Planning Department, the same author says that Uzbekistan vineyards covered slightly over 79,000 acres in 1926, but by 1928 had grown to about 82,000 acres,[107] which constituted about 83 per cent of the total acreage of grapes in Turkestan. Nearly half of the vine acreage of Uzbekistan was in the Samarkand region in 1928.

PROSPECTS FOR EXPANSION

The first Five-Year Plan of the Soviet government contemplated doubling the acreage in grapes in Uzbekistan from 1928 to 1932. Although acreage and production data since 1928 are not available, Americans who have traveled in Turkestan believe that the vineyard increase has fallen far short of the Soviet goal. The government is probably being more immediately successful in increasing the quality of the dried-fruit output rather than the quantity.[108] Within another five or ten years, however, the quantity of the commercial raisin output might be substantially increased. Unless Russian raisin consumption grows ac-

[104] Not including Bessarabia and other lost territory. Annuaire Statistique Agraire. Moscow, 1928.

[105] Jaroshewich, N. K. Arboriculture and viticulture of Uzbekistan, 1926. [Original in Russian, translated title.]

[106] Berezkovskii, E. A. The vine industry of Uzbekistan. In: Journal for Reconstruction of Farming. p. 117. April, 1929.

[107] Although these acreage data are from official sources and apparently the best available, they are probably only approximate. After bringing together and comparing estimates of the Russian Turkestan grape acreage from different sources for the years for which data are available from 1907 to 1928, and after attempting to secure reliable acreage data by provinces or counties from the Statistical Bureaus of the Turkestan Soviet Republics in 1925, M. A. Tupinov has concluded that no accurate data of this kind have ever been available for Russian Turkestan. (Essays on grape growing in middle Asia. [Original in Russian, translated title.] Bulletin of Applied Botany of Lenin Academy of Agricultural Sciences in U. S. S. R. 24:81–83. 1929–1930.)

[108] Elliott, T. H., and F. J. Mulligan in letter of July 28, 1932.

cordingly, increased exports to other countries would naturally result. According to Berezkovskii[109] the age distribution of the vineyards of Uzbekistan in 1928 was as follows: one to five years old, 3 per cent; five to ten years, 12 per cent; ten to twenty-five years, 35 per cent; and twenty-five to fifty years old, more than 50 per cent.

In the past, grape growing has been a small-scale industry carried on by peasant farmers. Much of the vineyard acreage is within the mud walls of gardens and its expansion is limited by this fact and also by the small size of most native peasant farms, which are said to range commonly from only 5 to 15 acres in extent, with only about an acre of grapes or less per farm.[110] In discussing the prospects for increased grape production in Uzbekistan in 1929, Berezkovskii also states that the planned development of the grape industry is a task difficult of realization because the government is faced with the problem of the reconstruction of the whole farming system in many parts of Uzbekistan. Moreover, he says that conditions in the vine industry are rather unsatisfactory. There is a large percentage of old vineyards many of which have not been properly cared for; the soil has become exhausted in many instances because of lack of proper fertilizer, and cryptogamic disease and other diseases and pests have reduced yields. Peasant yields per acre, he states, have been reduced to almost half the pre-war average or from 3,600 to 4,500 pounds of grapes per acre to 2,200 to 2,700 pounds.

There are a number of other factors that would appear to be retarding the expansion of grape production and raisin exports of Uzbekistan. Grape growing is not as well adapted as many other crops to large-scale government farms under machine methods on the flat valley floors, where expansion of the cultivated acreage is largely taking place. Much of the unused acreage available for planting is adapted to growing cotton, and the Soviet government is said to be concentrating its efforts on expanding the acreage of this crop, which produces fairly good crops even on the flat alkali areas on the floors of the valleys.

The carrying out of official plans for vineyard expansion in Turkestan is also retarded by factors common to other crops. The native population is probably slower to adopt Soviet plans than Russian-speaking people in other parts of the Union. Lack of finances and bad management are known to have greatly handicapped the working out of government plans everywhere. In Turkestan, expansion of the cultivated area of all

[109] Berezkovskii, E. A. The vine industry of Uzbekistan. In: Journal for Reconstruction of Farming. p. 117. April, 1929.

[110] Berezkovskii, E. A. The vine industry of Uzbekistan. In: Journal for Reconstruction of Farming. p. 117. April, 1929.

crops is largely dependent upon irrigation. Davis[111] states that "a very ambitious plan of irrigation construction [for Turkestan] was projected [by the Soviet government], but the world-wide business depression greatly crippled the markets for Russian exports, and it became necessary to curtail or postpone most of the work. Therefore little of the irrigation program has been carried out so far except the preparation of plans for future development."

THE AUSTRALIAN RAISIN AND CURRANT INDUSTRY[112]

The cultivation of vine fruits in Australia dates back to the early settlement which started about the beginning of the Nineteenth Century. Vine cultivation gradually spread from New South Wales to Victoria and South Australia, which are now the outstanding raisin-producing areas of Australia (see table 40). Western Australia and Queensland have not become important as raisin producers. Since the Australians are

[111] Davis, Arthur Powell. Irrigation in Turkestan. Civil Engin. 2(1):5. 1932. This article contains an interesting map showing the chief physical features of Turkestan and its principal cities and railroad routes. In 1911 and in 1929 Mr. Davis was employed to investigate the possibilities of irrigation development in Turkestan.

[112] General sources used for this section in addition to those given in specific footnotes:

Arndt, Franz Rudolf. Fruit-growing under irrigation; under the climatic and geographical conditions pertaining to the Murray Valley. 214 p. The Hassell Press, Adelaide. 1930.

[Australia] Bureau of Census and Statistics. Official Yearbook.

[Australia] Development and Migration Commission. Dried fruits industry. 12 p. Canberra. 1930.

[Australia] Development and Migration Commission. Report on the dried fruits industry of Australia. 55 p. Melbourne. 1927.

[Australia] Dried Fruits Control Board. Fourth annual report, year ended 30th June, 1928. 10 p. Canberra. 1928.

[Australia] Dried Fruits Control Board. Fifth annual report, year ended 30th June, 1929. 10 p. Canberra. 1929.

[Australia] Laws, Statutes, etc. The Acts of the Parliament of the Commonwealth of Australia. Melbourne.

Australian Dried Fruit News, published monthly. Renmark, S. A.

[Great Britain] British Economic Mission. Report of the British Economic Mission. 42 p. Canberra. 1929.

New South Wales. Laws, Statutes, etc. The statutes of New South Wales. Sydney.

Smith, Neil Skene. Economic control; Australian experiments in "rationalisation" and "safeguarding." 306 p. P. S. King and Son, Ltd., London.

South Australia. Department of Agriculture. The currant industry. Bul. 68:1–12. 1912.

South Australia. Laws, Statutes, etc. Acts of Parliament. Adelaide.

South Australia. Government Gazette. Adelaide.

The Fruit World of Australasia, published monthly. Melbourne.

The Fruit World Annual. Melbourne.

Turnor, C. H. Land settlement for ex-service men in the oversea dominions; report to the Royal Colonial Institute. 63 p. The Saint Catherine Press, London. 1920.

Victoria, Australia. Laws, Statutes, etc. Acts of the Parliament, Acts 11 20, George V. Melbourne.

Western Australia. Government Gazette. Perth.

not a wine-drinking people and also because of the difficulties encountered in marketing their comparatively unknown wines in Europe, it was but natural that growers should shift to drying varieties. As a result, all of the above mentioned states, with the exception of Queensland, are raisin and currant producers of commercial importance.

TABLE 40

AUSTRALIAN RAISIN AND CURRANT PRODUCTION BY STATES, CALENDAR YEARS HARVESTED, AVERAGE 1928–1932, ANNUAL 1926–1932

State	1926	1927	1928	1929	1930	1931	1932	Average 1928-32	
Raisins									
	short tons	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*per cent*
New South Wales	1,297	2,299	1,727	3,365	4,670	2,575	10,853	4,638	10.1
Victoria	19,684	36,832	22,530	43,183	43,885	24,703	30,385	32,937	71.3
South Australia	6,230	9,095	3,088	11,790	11,830	8,887	924	7,304	15.8
Western Australia	540	496	907	674	730	596	3,603	1,302	2.8
Total Australia	27,751	48,722	28,252*	59,012*	61,115*	36,761	45,765	46,181	100.0
Currants									
	short tons	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*short tons*	*per cent*
New South Wales	344	509	254	547	607	482	606	499	2.8
Victoria	6,929	7,586	4,094	10,639	9,980	8,698	7,873	8,257	45.8
South Australia	5,820	4,909	2,823	9,192	9,065	8,327	8,935	7,668	42.6
Western Australia	611	1,285	1,369	1,468	1,492	1,904	1,680	1,583	8.8
Total Australia	13,704	14,289	8,540*	21,846*	21,144*	19,411	19,094	18,007	100.0

* Totals given for 1928–1930 do not agree exactly with corresponding production estimates shown in table 2, which are taken from an unofficial source.

Sources of data:
1926–1930: from Off. Yearbook of the Commonwealth [Australia] 1931.
1931 and 1932: from the Australian Dried Fruits Association.

DEVELOPMENT OF THE INDUSTRY

The Australian raisin and currant industry is of recent development. The production prior to 1900 was relatively unimportant and it was not until 1912 that exports of raisins and currants for the first time exceeded imports. During the last years of the War, high prices stimulated new plantings. In addition, the conflict at arms between Turkey and Greece, the two important producers of raisins and currants, lasted until 1922. The Smyrna region (Turkey in Asia) was the battlefield during this conflict, and hence was unable to supply the consuming markets with adequate quantities of raisins. As a result of this situation, the United Kingdom market was undersupplied. Prices rose to more than double those of pre-war years.

In view of the prosperity enjoyed by the Australian growers during that period, the raisin and currant industry in that country was considered to be one of the most profitable agricultural enterprises in which one could engage. The Commonwealth government itself settled, by

TABLE 41

AUSTRALIAN RAISIN AND CURRANT PRODUCTION, 1902, 1904–1933

Calendar year harvested	Raisins (includes sultanas)	Currants	Calendar year harvested	Raisins (includes sultanas)	Currants
	short tons	*short tons*		*short tons*	*short tons*
1902*	1,953	334	1918	8,474	6,136
			1919	9,541	7,430
1904*	3,725	1,002	1920	15,726	8,042
1905*	2,184	1,047	1921	9,418	7,647
1906*	3,074	1,173	1922	15,121	9,080
1907*	6,398	1,461	1923	20,876	11,755
1908*	5,214	1,702	1924	33,063	17,040
1909*	5,462	2,037	1925	29,876	13,050
1910*	6,096	3,554	1926	27,751	13,704
1911*	6,388	3,733	1927	48,722	14,289
1912*	7,704	5,270	1928†	28,252	8,540
1913*	8,116	5,631	1929‡	59,012	21,846
1914*	8,728	6,231	1930‡	61,115	21,144
1915	8,394	3,119	1931	36,761	19,411
1916	13,836	7,875	1932	45,765	19,094
1917	10,313	6,760	1933	67,952	18,866

* Data for 1902–1914 are for Victoria and South Australia only. There are no records of the production of raisins and currants separately in New South Wales and Western Australia, but the combined production of raisins and currants in these two states was only 337 tons in 1913 and 378 tons in 1914.

† The low production for 1928 was due to the disastrous effect of a frost experienced over practically the whole of the River Murray Valley.

‡ Totals given for 1928–1930 do not agree exactly with corresponding production estimates shown in table 2, which are taken from an unofficial source.

Sources of data:
1904–1909: from California State Board of Agriculture. Statistical Report, 1917, p. 157.
1902, 1910–1930: from Off. Yearbook of the Commonwealth [Australia.]
1931 and 1932: from the Australian Dried Fruits Association, unofficial data.
1933: unofficial estimate from: Foodstuffs 'Round the World, Canned and Dried Foods **9** (57): 2. 1933.

means of a vast legislative scheme, about 2,500 Australian and English ex-soldiers as raisin and currant producers. According to a recent statement of the Commonwealth Minister of Markets and Migration, the number of raisin and currant growers now totals about 6,000, but about 40,000 people depend directly on the industry. This artificial introduction of new producers was looked upon very unfavorably by the pre-war growers. The result of the settlement scheme naturally was a rapid increase in the annual output of raisins and currants. This is clearly shown in table 41. Table 42 shows that most of the increase in raisin production in recent years has consisted of sultanas.

While the combined production of raisins and currants in the three years 1929–1931 averaged about 73,000 short tons, Australian home con-

sumption is estimated at about 12,000 to 13,000 short tons annually. The bulk of the output, therefore, is exported. It was but natural that some difficulty should be encountered by Australia in marketing a crop which increased so rapidly. When the newly settled areas came into production in Australia, a decided slump occurred in world market prices. This made successful marketing still more difficult for the Australian growers.

TABLE 42

AUSTRALIAN PRODUCTION OF SULTANA AND LEXIA RAISINS, 1925–1933*

Year harvested	Total*	Sultanas	Lexias
	short tons	*short tons*	*short tons*
1925	28,587	22,868	5,719
1926	25,083	21,711	3,372
1927	49,016	43,074	5,942
1928	28,791	22,079	6,712
1929	59,388	51,520	7,868
1930	59,898	53,227	6,671
1931	36,761	29,251	7,510
1932	45,765	40,822	4,943
1933	67,952	59,815	8,137

* As official sources do not report the production of sultana and Lexia raisins separately, the data in this table are taken from unofficial sources; consequently data on total production through 1930 do not agree exactly with those in tables 40 and 41.

Sources of data:
1925–1927: from Commonwealth Dried Fruits Control Board, Seventh Annual Report, page 12.
1928–1932: from Australian Dried Fruits Association.
1933: from Foodstuffs 'Round the World, Canned and Dried Foods **9** (57): 2. 1933.

COMPETITIVE ASPECTS OF THE INDUSTRY

High Costs of Production.—The quality of Australian raisins and currants is at least as good as the product of the other producing sections of the world. The chief obstacle to the Australian industry is the relatively high cost of production. This was probably one of the main reasons why the industry maintained higher prices abroad than those of foreign competitors in the years 1925 to 1928, which resulted in seriously retarding sales and consumption of Australian raisins in the United Kingdom for several years.[113] Although land is cheap, labor is expensive, 60 per cent of the cost of production being represented by wages.[114] Moreover,

[113] See Shear, S. W., and R. M. Howe. Factors affecting California raisin sales and prices, 1922–1929. Hilgardia 6:87–91. 1931.

[114] Detailed information on the cost of producing raisins in Australia will be found in a report of the Australian Development and Migration Commission for 1930, entitled "Dried Fruit Industry." Much information drawn from it will be found in: Squire, E. C. Australian raisin and currant industry and trade. U. S. Dept. Com. Bur. of Foreign and Dom. Com. Trade Inform. Bul. 699. 1930.

practically the whole commercial dried-fruit output has to be grown on irrigated areas for which the Commonwealth must expend enormous sums. Only about 2,240 tons have been produced in Western Australia and South Australia on nonirrigated lands. The great distance from the European consuming centers is also a handicap to the industry because of the resulting high transportation costs.

It is safe to say that the Australian vineyardist cannot cut his production costs enough to offer his fruit profitably at the low prices prevailing in European markets since 1929. Other producing countries of the world offer raisins and currants at prices which never could be remunerative for an Australian grower. Australia, therefore, is almost entirely dependent upon its sales to countries with high purchasing power which grant her special duty preferences, such as the United Kingdom and Canada which take nearly all her exports.

Market Organization.—The Australian dried-fruit industry is well organized and there is scarcely any room for improving the economic status of the producers by further rationalization. The Australian Dried Fruits Association, which regulates marketing to a certain extent, as far as its members are concerned, includes more than 90 per cent of the raisin and currant producers, besides coöperative and privately owned packing sheds, coöperative selling organizations, agents, and wholesale dealers. Since the cost of production cannot be lowered much unless the entire economic system of Australia changes, Australian producers now recognize that there is not much to be done at home to relieve the situation. The industry, therefore, has set about developing several activities abroad, which for the time being are making it possible for producers in that country to continue operating. These activities are discussed in detail on pages 108 and 109.

TRADE POSITION

Australia's endeavor to market abroad much of her enormously increasing production has been rather successful, if one takes into consideration the difficulties that all producing countries have had to face on the international raisin and currant market in disposing of their exportable surpluses in recent years. Table 43 shows the rapid increase that has taken place in Australian raisin exports since the War. It is a bit surprising, too, to see that Australia has continued to import a few raisins from other countries.

Export Outlets.—The most noticeable feature of table 44 is the relative insignificance of Continental Europe, South America, and the Far East as export outlets for Australian raisins; this is also shown in a

striking way in table 46. Certain characteristics of Australian raisins and currants, mainly their sugary flavor, tend to restrict their sale in many European countries that prefer a tart flavor. The South American demand for Australian raisins and currants is relatively small and is limited somewhat by the small quantities produced in Argentina and

TABLE 43

AUSTRALIAN OVERSEAS IMPORTS AND EXPORTS OF RAISINS AND CURRANTS, 1903, 1912–1931

Years beginning July 1	Imports		Exports		Net exports	
	Raisins	Currants	Raisins	Currants	Raisins	Currants
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
1903*	1,237	8,641	699	93	*—538*	*—8,548*
1912*†	175	248	1,515	384	1,340	136
1913*	130	82	1,918	472	1,788	390
1914	77	30	1,184	930	1,107	900
1915	125	1,219	6,952	1,169	6,827	50
1916	45	2	5,622	6,525	5,577	6,523
1917	165	‡	3,958	4,935	3,793	4,935
1918	29	20	3,111	3,471	3,082	3,451
1919	42	3	8,840	7,948	8,798	7,945
1920	15	4	11,816	5,995	11,801	5,991
1921	219	4	13,206	10,941	12,987	10,937
1922	81	3	19,241	14,503	19,160	14,500
1923	434	4	26,400	16,459	25,966	16,455
1924	193	8	56,047	21,559	55,854	21,551
1925	103	15	35,557	18,845	35,454	18,830
1926	98	5	44,079	19,211	43,981	19,206
1927	108	‡	54,289	8,214	54,181	8,214
1928	331	1	75,207	29,851	74,876	29,850
1929	186	1	79,325	33,302	79,139	33,301
1930	1	‡	89,158	32,214	89,157	32,214
1931	1	1	65,977	30,252	65,976	30,251

* Calendar years.

† The imports of raisins exceeded the exports for all years prior to 1912, except in 1904, 1907, and 1908, which followed abnormally good seasons. The increasing production of currants led to an export surplus of all raisins and currants in 1912.

‡ Less than 500 pounds reported.

Sources of data:
Years previous to 1928 from Off. Yearbook of the Commonwealth of Australia.
1928–1931: from Commonwealth Bureau of Census and Statistics [Australia] Overseas Trade.

Chile. In addition, South American markets are supplied by California and Greece. Furthermore, geographically the Union of South Africa would be in a more favorable position than Australia to develop markets in South America, although up to the present the Union of South Africa has done very little business in the South American dried-fruit trade. These facts partially explain the absence of Continental European and South American countries as important Australian customers.

The Far East, which geographically should be Australia's logical export outlet, does not seem to offer great opportunities in this direction.

TABLE 44

AUSTRALIAN EXPORTS OF RAISINS AND CURRANTS BY COUNTRIES OF DESTINATION, CALENDAR YEAR 1913, FISCAL YEARS BEGINNING JULY 1, 1922–1931

Destination	1913*	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Currants, in 1,000 pounds											
United States	—†	140	140	31	84	165	—	76	0	39	17
Canada	142	185	96	389	432	2,157	4,392	5,591	2,251	4,489	4,034
United Kingdom	158	11,230	13,964	19,141	17,077	15,121	1,388	22,154	29,492	25,938	22,932
China	—	68	42	34	44	71	53	17	14	15	48
Hongkong	—	33	49	71	41	54	58	76	72	76	59
Japan	—	—	10	8	—	—	—	—	—	—	—
Dutch East Indies	—	159	163	161	118	293	176	272	254	275	400
Union of South Africa	73	861	772	715	183	427	732	535	245	126	640
New Zealand	76	1,721	1,109	942	785	848	1,279	986	782	1,112	1,858
Other countries	17	106	114	67	81	75	136	144	192	144	264
Total	466	14,503	16,459	21,559	18,845	19,211	8,214	29,851	33,302	32,214	30,252
Sultanas, in 1,000 pounds											
United States	—	—	—	—	—	—	—	—	—	631	160
Canada	117	—	—	27	214	771	2,038	3,516	3,966	17,130	19,046
United Kingdom	603	12,717	18,753	43,642	26,689	35,319	43,270	61,776	65,291	58,309	32,247
China	—	32	8	19	10	23	60	41	146	136	71
Hongkong	—	5	6	12	17	22	51	73	125	220	369
Dutch East Indies	—	56	59	32	60	87	64	110	168	233	229
Union of South Africa	97	57	‡	—	—	—	—	—	—	—	—
New Zealand	500	2,558	1,633	3,132	4,352	2,695	3,525	2,608	2,972	3,807	6,776
Other countries	18	56	81	46	69	177	147	191	566	527	372
Total	1,335	15,481	20,540	46,910	31,411	39,094	49,155	68,315	73,234	80,993	59,270
Other raisins,§ in 1,000 pounds											
United States	—	—	—	—	—	—	—	—	—	—	—
Canada	166	—	54	—	—	870	848	1,316	869	808	1,425
United Kingdom	347	3,201	5,745	7,873	4,043	3,921	4,213	5,512	5,102	7,133	4,966
Dutch East Indies	—	24	5	—	12	68	4	7	—	—	—
New Zealand	42	484	34	1,202	39	39	18	14	33	143	229
Other countries	25	50	21	60	52	87	50	43	88	81	86
Total	580	3,759	5,859	9,135	4,146	4,985	5,133	6,892	6,092	8,165	6,706

* When comparing the above totals with those in the preceding table on imports and exports, it will be noted that the 1913 figures show a slight difference. That is probably due to later revisions.

† Dashes indicate data not available. If any, they are included under "other countries."

‡ Less than 500 pounds.

§ More than 90 per cent consists of Lexias.

Source of data: Commonwealth Bureau of Census and Statistics [Australia]. Oversea trade.

With the exception of Japan, where only good grades are asked for, the Australian prices are still too high. None of the Far Eastern countries are interested in high-priced dried fruit at the present time. In other words, as far as the Japanese markets are concerned, the better qualities cannot be absorbed at prices remunerative to Australian growers.

The only remaining export outlets for Australian dried fruit are the countries of the British Empire, some of which not only have a relatively

TABLE 45

CANADIAN IMPORTS OF RAISINS FROM AUSTRALIA AND THE UNITED STATES, 1921–1931

Crop year beginning October 1	Total imports	United States	Australia	Percentage from	
				United States	Australia
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*per cent*	*per cent*
1921	30,448	27,260	*	89.5	†
1922	38,520	36,517	5	94.8	†
1923	39,979	37,099	121	92.8	0.3
1924	39,930	37,193	99	93.1	0.2
1925	34,756	30,426	291	87.5	0.8
1926	40,888	37,145	1,707	90.8	4.2
1927	45,539	40,469	2,801	88.9	6.2
1928	47,020	41,031	4,314	87.3	9.2
1929	35,325	27,647	6,461	78.3	18.3
1930	40,548	21,965	17,731	54.2	43.7
1931	40,324	12,661	26,553	31.4	65.8

* Less than 500 pounds.

† Less than one-tenth of one per cent.

Source of data: Compiled from Quarterly Reports of the Trade of Canada.

high purchasing power, but all of which are in a position to grant duty preferences more favorable than those provided for by most favored nation clauses.

British Tariff Preference.—The rapid development of the Australian raisin and currant industry and trade was made possible largely by the preference granted Australian fruit on the British market. Producers in Australia have recognized for many years that they could not compete on the world market under ordinary circumstances. For that reason, there has been a steady campaign for imperial preference not only on the British market but in the other markets of the British Commonwealth of Nations as well.

As a result of this campaign, duty preferences granted, particularly in the British market and in Canada, have resulted in larger quantities of currants and sultana raisins being shipped to those markets from Australia. Lexias—the Valencia type of unseeded, soda-dipped, sun-

dried Muscat raisin—are losing popularity in the United Kingdom, and expansion of their sale in that market is unlikely. Table 12 shows that Australian currants have practically replaced Greek currants in Canada, and table 45 shows that Australian raisins have been rapidly displacing California seedless raisins in that market in the last three years. It is the general opinion in Australian dried-fruit trade circles that exports of currants to Canada cannot be increased much, but that it will be possible to further displace California raisins in that market if the preferential advantages already granted are continued. On October 1, 1925, the Canadian import duty on raisins, which had previously been ⅔ cent a pound regardless of country of origin, was raised to 3 cents a pound on California raisins, while Australian raisins were admitted duty free. On June 1, 1931, the general duty which applies to raisins of non-British origin was raised to 4 cents. Possibly in the year 1934, the general duty may be lowered to 3 cents a pound again. All raisins imported from California are subject to this general duty, and in addition, raisins in cartons and in other packages smaller than a 25-pound box are subject to appraisal for dumping purposes at not less than 5¼ cents a pound, f.o.b. point of production. In effect this means that Canadian importers cannot buy California raisins in cartons and paper and cellophane bags at less than 5¼ cents a pound, f.o.b. California shipping points, regardless of how much lower the prevailing f.o.b. price for domestic sales is. If shipments to Canada are billed at less than 5¼ cents f.o.b. California, the Canadian customs authorities collect the difference as a dumping duty.[115]

THE BEGINNING OF GOVERNMENT AID

The raisin and currant industry of Australia has been the subject of Commonwealth and state aid in some form or other from the very beginning. A survey of these measures indicates that the whole history of government aid to the raisin and currant industry in Australia may be divided into two general phases. The first includes all measures designed to promote the development of the industry, such as irrigation aids, settlement policies, and credit schemes, while the second includes all measures designed to regulate and control production and trade.

Irrigation.—The most important features within the first phase are the irrigation schemes. The first irrigation project along the Murray River in Victoria was started in 1885 by two Americans, the Chaffey brothers, who had gained their experience in fruit growing and irriga-

[115] U. S. Dept. Com. Bur. Foreign and Dom. Com. Commerce Reports, p. 8. October 1, 1932.

tion in Riverside, California. This project was taken over by the Victorian government because of a critical financial situation. Rather soon other schemes were taken up and strongly supported by the various state governments. Development of the Australian raisin and currant industry was greatly facilitated by the government's taking care of the expenses for irrigation from the very beginning. A huge scheme, based upon the "River Murray Water Agreement" of 1914 between the Commonwealth government and the states of Victoria, South Australia, and New South Wales, was designed to insure the industry against water shortage. Construction was first started in 1917.

The present annual water rate for the majority of growers is around $17 an acre.[116] This new scheme is supposed ultimately to furnish sufficient water for doubling the total acreage under irrigated production in Australia. Dried-fruit production is centered on the lands along the Murray River and the potentialities of expanding the industry in this favorable region seem to be enormous. It will hardly be possible, however, to develop raisin and currant growing under these costly production conditions in competition with the other producing countries of the world, unless the people of the United Kingdom and the rest of the British Empire are willing permanently to pursue a policy of buying Empire-grown dried fruit exclusively at prices considerably higher than that for which raisins and currants can be produced in important producing countries other than Australia.

Settlement Policy and Loans.—The "Closer Settlement Policy" of the Australian government was of great importance in the development of the raisin and currant industry. The purpose of this policy was to prevent the Australian population from spreading too much throughout the country. The government, therefore, regulated and controlled the purchase and distribution of land. Owing to the fact that the government not only made free grants of land, but also provided for the financial resources of the settlers, the number of raisin and currant producers was easily increased in the Murray River basin where conditions were particularly favorable for expensive vine culture.

As already stated, (pages 102 to 104), the economic equilibrium of the Australian raisin and currant industry was disturbed by the settlement of returned soldiers after the World War. The first difficulty resulting from this policy seems to have made its appearance in 1924, when the Commonwealth government, by means of the Dried Fruit Advance Act,

[116] Detailed and comprehensive description of irrigation conditions in the Australian raisin and currant industry will be found in: Squires, E. C. Australian raisin and currant industry and trade. U. S. Dept. Com., Bur. of Foreign and Dom. Com. Trade Inform. Bul. 699. 1930.

provided for exceptional financial assistance to raisin and currant growers. Loans were granted to growers for use solely in farming operations, on dried fruit produced and forwarded to a packing shed, and also to exporters approved by the Ministry of Migration and Markets, at the annual interest rate of 6 per cent. The payment of the sums was taken care of by packing organizations and merchants appointed for this purpose by the government.

THE COMMONWEALTH DRIED FRUIT EXPORT CONTROL BOARD

It so happened that when the newly settled areas came into bearing and production increased so considerably, world market prices dropped. The producer, who did not know where and how to market his share in the oversupply, was in danger of being stampeded into disorderly marketing. Moreover, irresponsible dealers began to trade on any basis because of their necessity for immediate cash returns. As there was still a considerable unexportable and permanent surplus on the home market, amounting after home consumption was deducted to about 15 to 20 million pounds, the Commonwealth government deemed it advisable to establish some sort of control over marketing. As the bulk of the crop is exported, an export control régime was set up in 1924, which is still functioning at the present time. The complete details of this export control measure are discussed in subsequent paragraphs.

Commonwealth and State Interests Not Identical.—Although the Commonwealth Customs Tariff Act of 1901 made Australia an economic unit in its trade relations with foreign countries, the Commonwealth government itself (according to the Federal Constitution) can interfere in the trade of the various Australian states only within certain limits. It is obvious, of course, that any export control measure adopted by the Commonwealth government affects the trade organizations of all the various states. When the Commonwealth government was empowered by the Dried Fruit Export Control Act of October 20, 1924, to establish the Commonwealth Dried Fruit Export Control Board,[117] the various state governments had to form similar boards in order to make the functioning of the Commonwealth Board as efficient as possible. Hence the multiplicity of dried-fruit boards in Australia.

These state boards are linked with the Commonwealth Board and with one another in that they are supposed to make all of their decisions on behalf of the dried-fruit industry as a whole, so that the action of one

[117] The activities of the Board are controlled by the Federal Department of Markets on the basis of the following acts: Dried Fruit Exports Act of 1924; Dried Fruit Export Charges Act 1924–1927; Dried Fruit Interstate Trade Act 1928; and the Dried Fruit Export Guaranty Act 1924–1925.

state board will not nullify the action of another or of the Commonwealth Board. The latter has no authority over the state boards and cannot tell them how to arrange matters. The uniformity in the legislative foundation of the boards, however, makes it possible to obtain at least some sort of uniformity in policy and actions for the dried-fruit industry as a whole.

The export control exercised by the Commonwealth Board is based on the retention principle. In other words, the Commonwealth Board determines the percentages of the output which can be exported or must be kept within the Commonwealth either for ordinary consumption or for industrial use (delivery to distilleries), in accordance with the price, the world market situation, and the actual exportable surplus available in Australia. The general policy is to make prices remunerative for the grower by preventing disorderly marketing and glutting of the market. Each producer of Australian dried fruits is expected, as far as practicable, to share proportionately in the home and the export trade.

The various state boards, however, have the same right as the Commonwealth Board, and they fix the percentage with regard to the apparent immediate needs of their particular state. They also recommend to the Commonwealth Board the export quotas to be employed. For that reason, there are frequent clashes of opinion between the Commonwealth Board and the various state boards. One state board, for example, may feel that in seasons when production of raisins and currants in its state is relatively small, growers within its jurisdiction could well afford not to export at all and that it would be more remunerative to sell the entire output within the sheltered Australian home market. Production in New South Wales averages around 1,600 tons annually, while the population consumes from 4,000 to 6,000 tons. The home market is, therefore, considered to be the better market. Accordingly, the state board invariably fixes export and home retention quotas that disagree with the quotas of the Commonwealth Board, which are fixed with a view to making all Australian growers share proportionately in the home and the export trade. Disputes in such matters have repeatedly taken place.

Thus, the efforts to effect stability of price in one state may be nullified by the action of producers in the adjoining state. It will be seen later how this is avoided (page 120). In general, it has been a difficult matter to bring about concerted action among these various boards. Serious thought is now being given to the possibility of effecting a change in the Commonwealth Constitution so as to remove the limitation of the inter-

ference by the Commonwealth government with the trade regulations of the various state governments.

Organization of the Commonwealth Export Control Board.—The Commonwealth Dried Fruit Export Control Board was brought into existence by the law of October 20, 1924, as a semiofficial organ. It constitutes a "body corporate" with perpetual succession and is capable of suing and being sued. The law establishes the relation between Board and growers as follows: "The Board in its corporate capacity shall be deemed to be the agent of the owners of all dried fruits of which the Board has accepted control. The mutual rights, obligations, and liabilities of the Board and the several owners shall, accordingly, be determined in accordance with the law governing the relations between principals and agents."[118]

The membership of this Board consists of four representatives elected by the growers in each of the four producing states; two members representing the dried-fruit trade, appointed by the Governor General; and one representative of the Commonwealth government. The Board is financed by a Dried Fruit Export Fund, which is established by sums derived from a special export tax imposed on all dried fruit exported. The income derived from the investment of these sums forms a part of the fund. The accounts of the Board are inspected by the Auditor General of the Commonwealth. In order to facilitate the activity of the Board, the law prescribes that traders in dried fruit have to apply for a special license in order to operate. The Board keeps a register of these licenses. It also can call upon any person to furnish such information in relation to the industry as is deemed necessary for the purpose of carrying out its activities. Persons who fail to report to the Board when called upon are liable to penalties.

Functions of the Board.—The main function of the Commonwealth Board is to stabilize the dried-fruit industry by preventing demoralization of the market, mainly by the establishment of remunerative prices. Knowing from the above compulsory reports the economic situation of the industry at home, and knowing what the foreign situation is through its agency in London and a special commercial representative in Canada, the Board decides which quantities can be exported and what minimum prices have to be accepted by the exporter. The Board is, of course, authorized to change these quotas and prices from time to time.

Marketing Under the Commonwealth Control Plan.—At the same time the Governor General prohibits the exportation of any dried fruit

[118] There has actually been a case (the James case) which shows that an exporter can claim indemnities for damages to his trade brought about by the activity of the Board.

unless the Board has granted an export license and the exporter has obtained a certificate of cleanliness and quality based on government inspection. The granting of this license affects, of course, the trade technique to a certain extent. The Australian exporter places his samples before his overseas customer by means of London agents and makes a contract with him. The sale of Australian dried fruit in Great Britain is based on a sample of the actual outturn and not upon standards adopted for the internal trade of Australia or for other markets.

Active salesmanship of the several approved agents receiving fruit in Great Britain on consignment[119] and on behalf of their Australian principals is not prevented by the Commonwealth Export Control Board. The agent can sell as much as he is capable of placing. The contract, however, must be submitted for examination to the London Agency of the Board.

The conditions under which a license or export permit (in case of consignments, a sales permit) is issued are the following: In case of shipment to Great Britain the exporter cannot complete the sale until the contracts have been approved by the London Agency; the application for a license must contain all of the particulars as to gross and net price c.i.f. (cost, insurance, and freight) and f.o.b., discount, commission, rebates, or any other allowances.

The conditions for a shipping license to New Zealand and other countries are similar. In the case of New Zealand, it is additionally required that the fruit be sold to such purchasers, through such agents, and in such quantities, as the Board may determine. In the case of other countries, the exporter must prove that the fruit has actually been sold for consumption outside of Australia at a price approved by the Board, and that the purchaser will not transship or reëxport the dried fruit to Great Britain.

It can be concluded from the foregoing that the Board actually can exercise a very strong measure of control. Even if the retention system of fixing export quotas does not work satisfactorily, there is still an opportunity for eliminating certain quantities from the market, at least temporarily, by sales-contract cancellations based on disapproval of the prices agreed upon by the parties concerned. Prices in all cases are supposed to be remunerative to the grower after deduction of production costs and handling expenses. This price-controlling device prevents Australian exporters from underselling one another and induces them to endeavor to obtain prices as high as possible because of the ever-

[119] Most of the Australian fruit is sent on consignment.

present risk of cancellation of the contract by the Board and subsequent delay and annoyance when agreeing upon a new contract.

Objections to the Present Control System.—The Australian system shows its weak point in free competition. It is the general opinion that control by means of combining retention and price-fixing on a sliding-scale basis according to the world market conditions, has kept the Australian dried-fruit industry fairly well organized. But what is going to happen when other producing countries undersell Australia? In that case neither the creation of an artificial shortage nor the disapproval of low contract prices by the Board can be of any material aid.[120]

The Board bases its approval or disapproval of prices demanded by Australian growers largely on the prices quoted by competitors. Owing to the competitive struggle and the crop situation in the various producing countries these prices fluctuate. The Australian stabilization system, therefore, cannot guarantee an equalization of annual returns and consequently no real stability to the industry. This is the main argument against the system that has been in effect in Australia since 1924.

Another objection is that this marketing system has brought about too much centralization. It is claimed that sales in the large industrial centers in England cannot be handled successfully because there is only one agency for the British market, i.e., the one in London. The obligation of submitting all transactions for the approval of the Board is also said to have caused buyers to purchase dried fruit from other countries rather than submit to the Australian methods.

ORGANIZATION OF THE STATE BOARDS

As already indicated, the formation of state boards was made necessary by constitutional limitations prohibiting the interference of the Commonwealth government in the trade activities of the separate states. Although it has been difficult at times to bring about concerted action among the various boards and the Commonwealth Board, the activity of the latter in the foreign market has been supported by the rationalizing activity of the state boards in the home market. The exact manner in which the state boards have coöperated with the Commonwealth Board will be discussed below (pages 115 to 120).

Victoria.—The control board for the State of Victoria was established by the Victoria Dried Fruits Act of December 30, 1924. The board consists of two members appointed by the State Minister of Agriculture and

[120] For a brief discussion of some of the difficulties of the Australian Dried Fruit Control Board involved in price-fixing from 1925 to 1930 see Shear, S. W., and R. M. Howe. Factors affecting California raisin sales and prices, 1922–1929. Hilgardia 6:87–89. 1931.

three members elected by the growers. It is financed by a levy on the growers for each pound of dried fruit produced. The board inspects the packing sheds, which have to be registered annually, and issues certificates of the quality of dried fruits intended for sale, which must correspond to the quality standards fixed by the board. It can refuse the registration of new packing sheds, if in the opinion of the state Governor there are sufficient sheds in the state. The board also prescribes branding or labeling of coverings and containers; i.e., the indication of grade description or marks to be used.

The marketing control exercised by the Victoria state board consists of fixing the percentages of the total output to be exported or marketed within the country. As previously stated (page 111), there must be an agreement with the Commonwealth Board regarding these quotas. The law, therefore, empowers the Premier of Victoria to join the Premiers of the Commonwealth and the states in any arrangements for concerted action in marketing problems.

If, for example, the investigation of the Commonwealth Board shows that (on account of adverse market conditions abroad) only a certain percentage of the crop in the State of Victoria can be exported (in order that the main purpose of the entire control scheme may be realized), and if, as a result of these circumstances there should remain an unconsumable surplus in Australia, then the State Minister of Agriculture is authorized to expropriate, or purchase, any dried fruits grown or dried in Victoria. One can see that this possibility of intervention purchases by the state constitutes the support given to the policy of the Commonwealth Board so far as the export quota is concerned. On the other hand, it is also a relief measure to protect the grower. In addition the board is empowered to handle such quantities as have not been acquired by the Minister.

In order that the government may always have expert knowledge of the position of the market, growers are compelled to make returns on the quantities held. The State Minister of Agriculture also requires that he be kept informed by telegram or letter concerning the quantities to be delivered to him or to the board. Unlike the Commonwealth Board, the state board is not liable for the result of its actions. No claim or demand can be made against it. The state board may also undertake advertising campaigns in Victoria.

South Australia.—The legislation providing for a state control board in South Australia was enacted on December 24, 1924, with the reservation, however, that it would not be enforced unless the State of Victoria enacted a law substantially similar to it. The organization of the South

Australian board corresponds to that of the Victorian, i.e., three grower members and two government officials, and financed by levy on growers per pound produced. The control is exercised in the same manner as in Victoria. Growers, packers, and dealers must register and are obliged under penalty to furnish any requested particulars about their business activities. The fixing of the export quota is supposed to be in agreement with that suggested by the Commonwealth Board.

As in Victoria, the State Minister of Agriculture may purchase or acquire any dried fruit or may authorize the board to do so. In several respects, however, the power of the South Australian board is greater than that of Victoria. The South Australian board, for example, may open wholesale or retail shops or depots for the sale of the quantities expropriated by it. It can fix the minimum remuneration to be paid to dealers for the sale or the distribution of dried fruit and the maximum prices to be charged for wholesale and retail sales. In addition the South Australian board is charged with the task of advertising and of promoting the sale and consumption of dried fruit in South Australia.

Western Australia.—In Western Australia a board, subject to control by the State Minister of Agriculture, was not formed until December 24, 1926. As in the case of the two states already mentioned, this board consists of three growers and two government representatives. It is financed by a levy on growers and it exercises control in exactly the same way as the South Australian board. It also fixes the remuneration to be paid to dealers for the sale of the fruit. Unlike the South Australian, but like the Victorian board, it can issue regulations for standards of quality and for branding and labeling. There are also provisions for an advertising campaign.

New South Wales.—The state of New South Wales can easily sell all of its small production of raisins and currants within its own boundaries on account of its large population (page 112), which represents somewhat more than one-third of the total for all Australia. For that reason growers have little or no interest in compulsory exports. It was not until February 17, 1927, that an agreement was arrived at whereby a quota might be fixed for New South Wales providing such action meets with the approval of 70 per cent of the state growers. The control board in New South Wales has only three members as against five for the boards in other states. One of the members on this New South Wales board is a government official, one a representative of growers operating in certain irrigation districts, and one a representative of the rest of New South Wales growers. The organization, control functions, and liability of the board correspond with those of the other state boards. In the case of New

TABLE 46

RAISIN IMPORTS INTO PRINCIPAL IMPORTING COUNTRIES BY COUNTRY FROM WHICH IMPORTED, CALENDAR YEAR AVERAGES, 1909–1913, 1921–1925, AND 1926–1930

Importing country and years	Country from which imported							
	Total	United States	Australia	Turkey	Spain	Greece*	Union of South Africa	Other countries†
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom‡:								
1909-1913	80,733	964	568	41,537	28,797	4,282*	§	4,585
1921-1925	119,261	25,564	23,926	29,329	18,784	9,525*	6,119	6,014
1926-1930	159,887	52,297	54,734	23,208	15,732	7,789*	3,329	2,798
Germany:								
1909-1913	39,990	376	§	33,761	1,175	1,662	§	3,016
1921-1925	27,009	2,351	§	18,204	574	4,419	§	1,461
1926-1930	69,909	16,937	§	36,823	265	12,216	§	3,668
Canada:								
1909-1913	22,331	12,068	§	1,782	7,719	§	§	762
1921-1925	34,537	31,773	60‖	959	1,312	§	81¶	†
1926-1930	40,662	34,371	4,285	516	751	§	211	528
France:								
1909-1913	17,540	§	§	7,025	4,839	4,880	§	796
1921-1925	9,575	241**	§	1,112	4,183	3,675	§	†
1926-1930	12,795	3,085	§	869	3,976	1,992	§	2,873
Netherlands:								
1909-1913	10,931	10	§	9,354	532	92	§	943
1921-1925	13,792	2,693	§	5,522	740**	2,276	§	†
1926-1930	23,184	10,602	§	9,012	457	1,293	§	1,820
Belgium:								
1909-1913	5,133	28¶	§	2,994	476	101	§	†
1921-1925	7,090	667‖	§	2,580	475	297	§	†
1926-1930	11,246	3,680	§	2,767	698	425¶	§	†
New Zealand:								
1909-1913	4,681	2,408	328	255	43	316	§	1,331
1921-1925	6,751	3,525	2,550	574	34	39	§	29
1926-1930	9,016	5,576	3,246	129	62	1	§	2
Denmark:								
1909-1913	4,229	208	§	§	2,883	§	§	1,138
1921-1925	3,960	1,655	§	§	1,481	§	§	824
1926-1930	5,674	4,440	§	§	533	§	§	701
United States:								
1909-1913††	3,582	§	0	1,445	1,781	21	0	335
1921-1925	11,887	§	24	2,783	3,559	2,487	1,597	1,437
1926-1930	2,688	§	‡‡	572	1,259	216	358	283
Sweden:								
1909-1913	3,623	98¶	1**	140	2,954	98‖	§	†
1921-1925	3,077	586	§	123	1,828	82	§	458
1926-1930	4,714	2,958	§	53	1,205	19	§	479

TABLE 46—(*Concluded*)

Importing country and years	Country from which imported							
	Total	United States	Australia	Turkey	Spain	Greece*	Union of South Africa	Other countries†
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Norway:								
1909-1913	3,114	20¶	§	500	1,498	165	§	†
1921-1925	3,393	818‖	§	334	717	555	§	†
1926-1930	4,247	2,369‖	§	194‖	908‖	140‖	§	†
Italy:								
1909-1913	2,773	1	§	1,380	574	331	§	487
1921-1925	2,298	22¶	§	975¶	237¶	1,763¶	§	†
1926-1930	5,272	316¶	§	1,406¶	1,172¶	2,285¶	§	†
Switzerland:								
1909-1913	2,076	2	§	419	1,148	485	§	22
1921-1925	1,751	46	§	233	568	871	§	33
1926-1930	2,641	682	§	538	471	947	§	3
Poland:								
1909-1913§§	§§	§§	§§	§§	§§	§§	§§	§§
1924-1925**	5,755	§	§	558	§	0	§	5,197
1926-1930	2,114	362¶	§	463	§	182	§	†
Irish Free State:‡								
1924-1925**	4,648	§	§	§	399	§	§	4,249
1926-1930	6,011	§	§	§	516‖	§	§	†
Egypt:								
1909-1913§§	§§	§§	§§	§§	§§	§§	§§	§§
1921-1925	4,144	§	§	519	§	1,950	§	1,675
1926-1930	3,851	§	§	1,105	§	870	§	1,876
China:‖‖								
1909-1913§§	§§	§§	§§	§§	§§	§§	§§	§§
1923-1925‖	4,843	3,798	47	§	§	§	§	998
1926-1930	6,073	4,823	62	§	§	§	§	1,188
Czechoslovakia:								
1909-1913§§	§§	§§	§§	§§	§§	§§	§§	§§
1921-1925	3,734	5	§	250	§	228	§	3,251
1926-1930	6,434	316	§	1,480	§	2,491	§	2,147

* For the United Kingdom, imports from Crete are excluded for 1909–1913 and included for 1921–1925 and 1926–1930. It is probable that the same is true of imports from Greece for other importing countries, since Crete did not come under Greek rule until 1912.

† Data on imports from "other countries" have been computed by subtracting the sum of imports given for specified countries from total exports. In all cases where irregular averages are given for one or more countries of origin, imports from "other countries" cannot be computed accurately and hence are omitted.

‡ The Irish Free State is included with the United Kingdom previous to April 1, 1923.

§ If any, included in "other countries."

‖ Four-year average.

¶ Three-year average.

** Two-year average.

†† Year beginning July 1.

‡‡ Less than 500 pounds.

§§ Data not available.

‖‖ Includes currants.

Sources of data:

Compiled from official sources by the Foreign Agricultural Service of the U. S. Department of Agriculture. Data for 1930 in some instances may be preliminary and therefore the 1926–1930 averages may be subject to minor changes.

South Wales there are, of course, no legislative provisions for an advertising campaign. Nevertheless, publicity is obtained by propaganda under the auspices of the board in schools, etc.

Concerted Action of the State Boards.—While South Australia and Western Australia exercise a sort of indirect price policy on the home market by fixing the remuneration to be received by dealers for the sale of raisins and currants, a uniform price policy prevails in all four states as far as the unexportable and unconsumable surplus is concerned. Such surpluses, as has already been mentioned, are bought by the boards or by the State Ministers of Agriculture. Growers are paid an "export parity price" for these quantities. This price is equal to either the assumed or the actual selling price of Australian raisins and currants in London, less the cost of freight, insurance, exchange, duties, and other charges.

Mention has been made of the fact (page 112) that a state, when fixing an export quota lower than those of the adjoining states, could exploit the home market in the other states by shipping its surplus into them, obtain a good profit, and save the trouble connected with marketing in Great Britain. The state boards try to avoid this practice by fixing the shipment quotas of each state for interstate trade, which they determine after having consulted each other. Victoria, for example, when allowed by the Commonwealth Board to export abroad 80 per cent of its output, cannot sell the remaining 20 per cent in New South Wales in competition with growers there. But because of its greater population and the surplus available in other states, the New South Wales government may allow 5 per cent of the Victorian crop to be marketed in New South Wales.

New South Wales has always allowed a certain percentage of raisins and currants from other states to be marketed within its boundaries but it has no local state surplus for which it can exercise a state price policy as do the other state boards. The New South Wales theoretical surplus consists only of that part of the output which, in accordance with the ruling of the Commonwealth Board, is not to leave the country, but which must be sold within the state itself. Complaints are often made that the raisins shipped into New South Wales from other states are being offered at cut prices and that they are depressing the prices of the New South Wales crop. Because of this situation there has always been considerable difficulty between the Commonwealth Board and the state boards, on the one hand, and the New South Wales board, on the other, in agreeing upon export quotas.

OTHER FORMS OF GOVERNMENT AID

The Commonwealth Board is aiding the Australian dried-fruit industry in a direct way by undertaking the insurance against loss of all dried fruit until it is disposed of either in the Commonwealth or abroad. It may also supervise and regulate the conditions under which the fruit is handled, stored, and shipped. The Board effected for the grower, during the first three years of its activities, a total saving in freight and insurance of about $194,600. In a shipping conference in 1929, between overseas shipping interests and Australian dried-fruit traders, it again used its influence to secure the lowest possible rates. In 1930 the Board made a trial shipment of raisins and currants to London in order to test the practicability of water-tight containers made from wood pulp. The fruit was first sterilized in hydro-vacuum kilns and then placed in these containers, which are said to be insect and fungi proof and considerably cheaper than tin containers. These activities serve to indicate the various directions in which the Commonwealth Board is attempting to aid the industry.

The Australian raisin and currant industry has shown an amazing development notwithstanding the difficulties growing out of the world-market situation since the War. The government of Australia has made every effort to support the industry and has also tried to stabilize it by attempting to check too rapid expansion. The state governments have definitely discouraged further plantings by not subsidizing new enterprises. A coöperative packing and selling organization proposed by the Development and Migration Commission some years ago, which was to undertake the handling of the entire Australian pack between grower and merchant has not been established. It seems as if the Australian Dried Fruits Association does the service of this proposed pool.

Publicity Activity.—In general, it has been recognized that the exportable-surplus question in Australia could be solved if the Australian people would eat more raisins and currants. The home propaganda for increasing consumption is very active. The state governments foster it strongly. The state railroads participate in advertising campaigns by distributing recipe books, by displaying giant posters at the stations, and by selling dried fruit in the official railroad fruit stalls and refreshment rooms.

The major portion of the income derived by the Commonwealth Board from the levy on exports is spent for publicity campaigns overseas. The Commonwealth government carries on a publicity scheme in Great

Britain which covers dried fruit, fresh and canned fruits, honey, and dairy produce. The government contributes to the maintenance of this campaign to the extent of about $243,000 annually. The Australian dried-fruit industry has spent the following sums in these advertising campaigns: 1926, $17,000; 1927, $97,300; 1928, $121,650; 1929, $97,300.

The British Empire Marketing Board.—The efforts of the Commonwealth government are supported by the British Empire government

TABLE 47

UNITED KINGDOM IMPORTS OF RAISINS FROM SPECIFIED COUNTRIES, AVERAGE 1909–1913, ANNUAL 1921–1932

Calendar year	Australia	United States	Turkey	Spain	Greece and Crete	Union of South Africa	Other countries	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Average:								
1909-1913	568	964	41,537	28,797	4,282*	†	4,585	80,733
Annual:								
1921	6,966	4,138	32,465	16,854	6,485	5,694	8,950	81,552
1922	10,086	40,167	25,719	21,807	10,009	10,536	12,752	131,076
1923	20,961	22,319	46,053	16,350	9,791	4,922	6,123	126,519
1924	42,183	20,105	29,905	18,848	13,012	5,369	1,466	130,888
1925	39,436	41,092	12,502	20,062	8,327	4,087	766	126,272
1926	24,466	44,964	31,035	16,867	8,910	3,585	337	130,164
1927	63,285	59,505	24,239	19,938	4,402	3,238	3,724	178,331
1928	32,012	77,434	19,392	13,046	7,762	5,066	1,415	156,127
1929	80,619	43,825	25,254	13,765	9,378	2,477	4,161	179,478
1930	73,282	35,322	15,805	13,995	8,319	2,280	4,730	153,733
1931	41,990	51,056	11,829	14,137	7,044	6,104	6,899	139,059
1932	33,767	50,818	45,284	14,667	14,687	6,447	22,288	187,958

* Excluding Crete.

† A very few included in "other countries."

Sources of data:
Compiled from Monthly Accounts Relating to the Trade and Navigation of the United King dom, December Issues and Annual Statement of the Trade of the United Kingdom.

which, in May, 1926, set up a marketing institution, known as the British Empire Marketing Board, to promote the sale and consumption of Empire merchandise. Endowed with funds ranging from $2,000,000 to $3,000,000 annually, this Board furthers the marketing of Empire products in the United Kingdom and establishes a means whereby the various dominions and colonies can coöperate more directly in the interest of their specific products. By direct propaganda (newspaper advertisements and articles, posters, distribution of postal cards, recipe books for cooking with Empire goods, fruit calendars, exhibitions, lectures, radio talks, and movies), the Board advocates the consumption of Empire-grown commodities. Following the slogan of "Empire Con-

sciousness," some of the largest biscuit and cake manufacturers have undertaken to use Australian dried fruit exclusively in their products. The combined effect of preferential import tariffs and favorable money exchange rates and the efforts of the British Empire Marketing Board and of the Australian government to promote the sale of Australian fruit is shown best by the increasing imports of Australian raisins into the United Kingdom and Canada (tables 45, 46, and 48).

In 1927, the Board invited an expert representative of the Australian dried-fruit industry to visit London for the purpose of studying the requirements of the British market. The report of this expert, who was also a producer-elected member of the Commonwealth Dried Fruit Export Control Board as well as the Chairman of the Australian Dried Fruits Association (comprising 90 per cent of the producers), has been published by the British Empire Marketing Board.[121] This expert also proceeded to California where he made a survey of American conditions at first hand.

In addition, the British Empire Marketing Board carries on economic investigations of wholesale and retail market conditions affecting the sale of Australian and other Empire dried fruits. Upon the condition that the Australian Commonwealth government would contribute a certain sum, the British Empire Marketing Board has made a grant of about $24,300 for research on insects in dried fruit. Another grant, under the same condition, amounting to about $121,650 has been made for the establishment of an organization to pursue entomological investigations in Australia. A third grant, amounting to about $43,794, provided for the sending of a mission to Australia to investigate various matters affecting the development of trade between Great Britain and the Commonwealth. It is to be supposed that the raisin and currant industry has also been taken into consideration by this mission. There is, finally, within the British Empire Marketing Board a special subcommittee for dried-fruit questions.

[121] Howie, H. D. Report on marketing of Australian dried fruits. London. [Great Britain] Empire Marketing Board. Special Report No. 2:1–33. 1928.

RAISIN AND CURRANT INDUSTRY OF THE UNION OF SOUTH AFRICA[122]

In pre-war times the Union of South Africa was a raisin and currant-importing country. Since 1917, however, there has been an annual export surplus. This has fluctuated rather violently, and at times, especially in the beginning of the last decade, was eight to ten times in excess of imports. The imports show a remarkable stability, remaining around 1 millon pounds annually. In general, however, the Union of South Africa must now be considered as a competitor on the world raisin market.

PRODUCTION TREND

Practically all of the raisins produced in South Africa are grown in the southwestern part of the Cape of Good Hope Province. Both Muscat and sultana raisins are produced,[123] but Muscats are still in the majority in both production and exports (tables 48 and 49). The Muscat of Alexandria, known locally as the "White Hanepoot," is used more for loose or stemmed raisins although some are dried as clusters (table 48). The small production of currants is mostly of the Greek Zante variety.[124] In addition to these eating varieties, Hermitage (Cinsaut) and other wine-making varieties are grown, although on a considerably smaller scale, and a small portion of the crop has been dried in some years since the War.

Unsatisfactory climatic conditions resulted in a larger portion of the

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[122] General sources used for this section in addition to those given in specific footnotes:

Cross, C. M. P. Dried-fruit industry and trade of South Africa. U. S. Dept. Com. Bur. of Foreign and Dom. Com. Trade Inform. Bul. 676:1–11. 1930.

Davis, R. A. Fruit growing in South Africa. 532 p. Central News Agency, Ltd., Johannesburg. 1928.

[Union of South Africa] Government Gazette, published weekly. Pretoria.

[Union of South Africa] Committee on fruit export trade. Report of committee of inquiry upon certain matters in connection with the fruit export trade of South Africa. 14 p. Cape Town. 1925.

Union of South Africa. Department of Agriculture. Dried fruits. Bul. 67:1–7. Pretoria. 1929.

Union of South Africa. Department of Agriculture. Handbook for farmers in South Africa. 766 p. Pretoria. 1929.

Union of South Africa. Office of Census and Statistics. Official Yearbook of the Union of South Africa. Pretoria.

[Union of South Africa] Railways and Harbors Board. Farming opportunities in the Union of South Africa. 1926.

[123] Wheeler, L. A. International trade in dried fruits. U. S. Dept. Com. Bur. Foreign and Dom. Com. Trade Promotion Series No. 44:30. 1927.

[124] "The real Zante currant grape was not imported into the Union until 1916, but it is now being grown fairly extensively, especially in the southwestern districts of the Cape." (From: Official Yearbook of the Union of South Africa, p. 427.) The Cape currant, a kind of dwarf seedless Muscat possessing a pleasing flavor, is cultivated on a very small noncommercial scale.

1929 raisin-grape crop being diverted into wine-making than usual. To some extent this glutted the wineries, and wine makers complained of overproduction.[125] The raisin grape is suited only for the cheaper grades of wine; this makes it difficult to sell South African wine competitively

TABLE 48

RAISIN AND CURRANT PRODUCTION* AND EXPORTS OF THE UNION OF SOUTH AFRICA, 1904, 1911, 1918–1933

Year harvested	Production					Exports†	
	Muscats		Sultanas	Raisins, total	Currants	Raisins	Currants
	Clusters	Loose					
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
1904‡	61	1,727	43	1,831	8	—§	—
1911	125	2,231	158	2,514	11	—	—
1918	496	4,716	1,149	6,361	114	3,215	1
1919	270	3,824	821	4,915	68	4,005	3
1920	412	3,907	853	5,172	68	3,031	5
1921	1,107	5,452	1,835	8,394	78	6,984	5
1922	3,028	10,114	2,499	15,641	119	11,873	1
1923	2,215	5,892	3,714	11,821	179	5,337	3
1924	2,913	6,239	1,894	11,046	214	7,900	5
1925	2,542	4,613	2,164	9,319	200	4,854	1
1926	2,060	3,949	3,120	9,129	182	4,953	2
1927‖	3,446	3,330	3,515	10,291	218	3,406	—
1928‖	3,561	3,223	4,044	10,828	192	5,006	1
1929‖	3,178	3,381	3,369	9,928	431	2,788	4
1930‖	552	5,452	3,000	9,004	616	2,369	1
1931	—	5,400¶	3,900	9,300	450	6,292	1
1932	—	5,100¶	4,200	9,300	450	6,458	**
1933	—	6,100¶	4,200	10,300	450	7,400	1

* Data include raisins dried on farms only and exclude the small quantities dried in factories.

† Export data are for calendar years.

‡ Data for 1904 are for the Cape Province only.

§ Dashes indicate data not available.

‖ Denotes fruit sold (farms only).

¶ Data given for 1931-1933 include both loose and cluster Muscats and may include small quantities of dried wine grapes in addition.

** Less than 500 pounds.

Sources of data:
Production data 1904-1930: from Off. Yearbooks of the Union of South Africa.
Production data 1931-1933 and export data for all years from: C. C. Taylor, U. S. Agricultural Attaché, Pretoria, in: Federal-State Market News Service, South African Dried Fruit Reports for February, 1933, pp. 2-3; for January, 1933, p. 4; and for June, 1933, p. 1. (Mimeo.) Sacramento, California.

in Europe after transportation charges are paid. The wine producers have attempted to protect the wine market by paying a bounty to raisin producers, amounting to about 2 cents for every pound of raisins dried, and this withholds fresh raisin grapes from being worked into wine. It is claimed that this bounty has tended to maintain the production of

[125] Reports from U. S. Consul Cecil M. P. Cross.

raisins at the level of previous years. It was still in effect in 1931.[126] The production of dried wine grapes for wine production exclusively seems to have had some importance in former years, but it is of relatively little importance at the present time.

TABLE 49

OVERSEAS EXPORTS OF MUSCAT AND SULTANA RAISINS FROM THE UNION OF SOUTH AFRICA, 1927–1933

Calendar year	Muscat*	Sultana	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
1927	1,981	1,425	3,406
1928	2,245	2,762	5,007
1929	1,556	1,232	2,788
1930	1,013	1,356	2,369
1931	3,735	2,557	6,292
1932	3,556	2,902	6,458
1933†	3,000	4,400	7,400

* Designated as raisins in source from which copied but are presumably all Muscats except for a few dried wine grapes.

† Estimated.

Sources of data:

1927-1931: are from Off. Yearbooks of the Union of South Africa and are estimates of the Department of Agriculture of the Union.

1932 and 1933: are from C. C. Taylor, U. S. Agricultural Attaché, Pretoria. See: Federal-State Market News Service. Dried Fruit Report (for South Africa), for January, 1933, p. 4; and for June, 1933, p. 1. (Mimeo.) Sacramento, California.

EXPORT OUTLETS

Table 48 shows that the raisin export trade of the Union of South Africa was of no importance before the War. However, it received considerable stimulus during the War when the Mediterranean countries found it exceedingly difficult to get their raisins and currants to European markets. Most of the big increase in raisin exports has gone to the United Kingdom, which still remains by far the most important customer, although, since 1923, Canada has become of some importance as an outlet because South African raisins have been admitted duty free (see table 50). At the peak of the Union's total annual raisin-export business, 1922, shipments to the British market had increased to the point of constituting 8 per cent of total imports of raisins into the United Kingdom, as compared with 3.5 per cent in 1919. The average of the five years 1928–1932 was 3 per cent. The lowest figure since 1922 was 1.5 per cent in 1930 and the highest 4.4 per cent in 1931.

In spite of the tariff preference and propaganda favorable to raisins produced in the British Empire, United Kingdom imports from South

[126] According to a cable of March 13, 1931, from C. C. Taylor, U. S. Agricultural Attaché, Pretoria, Union of South Africa.

Africa have declined greatly since they reached the peak of 12,534,000 pounds for the year 1922. Australia has been able to appropriate most of this advantage for her raisins. The Union's exports to England have constituted such a large majority of its total exports that naturally the total has declined just about as much as its exports to the United Kingdom. As table 51 shows, the only countries to which raisin exports from

TABLE 50

EXPORTS* OF RAISINS AND CURRANTS FROM THE UNION OF SOUTH AFRICA, BY COUNTRIES OF DESTINATION, CALENDAR YEARS, AVERAGES 1909–1913, 1922–1926, ANNUAL 1927–1932

Country	Average† 1909-1913	Average 1922-1926	1927	1928	1929	1930‡	1931‡	1932‡
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
United Kingdom	2	5,624	3,454	5,259	2,472	2,285	6,081	6,422
Germany	—‖	245	2	6	8	0	24	—
Netherlands	—	93	—	1	0	0	12	—
Canada	—	10	102	415	235	54	161	56
United States	—	569	—	7	0	0	—	—
African countries	8	24	54	63	62	74	107	37
Other countries	9	20	1	1	0	0	20	14
Total raisins	19†	6,585	3,613	5,752	2,777	2,413‡§	6,405§	6,529‡§
Total currants	0	2	10	6	12	—‡	—‡	—‡

* Does not include exports to Southwest Africa or Rhodesia, but includes overland exports to other countries. It will be noted that the total exports of raisins reported by the Department of Customs and Excise as given in this table do not agree exactly with those reported by the Department of Agriculture, table 48. The Annual Customs Reports include overland exports; the data of the Department of Agriculture do not include overland shipments to Belgian Congo and the Portuguese colonies. The Customs Reports cut off December 31 as with documents executed and not with ships sailed that day, in contrast with practices of the Department of Agriculture. See: Federal-State Market News Service. Dried Fruit Report for South Africa for January, 1933. p. 5. February 23, 1933. (Mimeo.) Sacramento, California.

† Includes figs and currants.

‡ Exports of currants included in raisin data in 1930 and 1931.

§ Total exports. May include 1,000 to 2,000 pounds of imported merchandise reëxported.

‖ Dashes indicate data not available. If any, they are included under "other countries."

Sources of data:
Annual Statement of the Trade and Shipping of the Union of South Africa, except for data on currants 1922-1928 which are from U. S. Agricultural Attaché, C. C. Taylor, Pretoria, South Africa.

the Union have increased since 1922 are other African countries, more particularly the neighboring countries of Southern and Northern Rhodesia and of the Southwest Africa Protectorate.

For several years after the War a considerable tonnage of dried wine grapes was exported from South Africa and included in the official statistics on raisin exports. Probably a large part of the exports to the United States shown in table 50 consisted of dried wine grapes rather than table raisins. It is believed that part of the apparent decline in the Union's export of raisins in recent years has been due to decreased exports of dried wine grapes.

PROSPECTS FOR THE INDUSTRY

Part of the decrease in the Union's raisin exports in recent years appears to be due to the unsatisfactory weather conditions which have prevailed during some recent harvesting and drying seasons. Moreover, the market for South African raisins of the bleached sultana type has been injured in recent years by the restriction of the sulfur content in

TABLE 51

RAISIN AND CURRANT EXPORTS FROM THE UNION OF SOUTH AFRICA TO AFRICAN COUNTRIES, 1920–1932

Calendar year	Northern and Southern Rhodesia and Southwest Africa*	Other African countries	Total
	1,000 pounds	*1,000 pounds*	*1,000 pounds*
1920	116	23	139
1921	80	24	104
1922	104	23	127
1923	126	26	152
1924	141	35	176
1925	141	20	161
1926	144	26	170
1927	194	54	248
1928	216	63	279
1929	254	62	316
1930	213†	73	286
1931	276†	106	382
1932	230†	34	264

* Data for 1920-1929 are imports of South African raisins into the countries indicated.

† Estimated. See source of data below.

Sources of data:

Data for imports into Northern and Southern Rhodesia and Southwest Africa for 1920-1929 from the Department of Customs and Excise. Data for 1930-1932 from U. S. Agricultural Attaché, C. C. Taylor, Pretoria, South Africa. Data were estimated from the total exports of dried fruit reported by the Dept. of Customs and Excise at the proportion indicated by Fischer's estimates of domestic consumption. See: Federal-State Market News Service. February Dried Fruit Report for South Africa. p. 2, 3, 4. (Mimeo.) Sacramento, California.

Data on exports to other South African countries are from the Dept. of Customs and Excise, Annual Statement of the Trade and Shipping of the Union of South Africa.

sultanas to 750 parts per million in the United Kingdom market. A similar regulation (Pure Food Act) has been in force in the Union of South Africa itself since 1928. It appears to be difficult for the South African industry to produce a good bleached sultana that will meet these restrictions in sulfur content.

These handicaps make it difficult not only to exploit the opportunities of the home market, but in addition, to compete, under the present conditions of the world raisin market, with the excellent unbleached sul-

tanas available from other countries, even in those Northern Hemisphere markets where there is no sulfur dioxide restriction. The South African grower cannot offer sultana raisins of the same quality at more favorable prices than California or Turkey in foreign markets. In fact, the African markets surrounding the Union have taken increasing quantities of sultanas from the United States in recent years. This has even been true of the Union of South Africa itself.[127] One might venture the conclusion that the future of the sultana industry of the Union will probably depend largely upon British Empire preferences, a protected home market, and the development of African markets south of the Equator. If progress cannot be made in these directions, the prospect for expansion of the raisin industry is questionable.

With the great shift in demand that has taken place the world over, from seeded to seedless raisin, there appears to be no incentive for South Africa to expand Muscat raisin production and exports. The outlook for the South African currant industry, likewise, is not promising. In spite of slightly increasing exports to African countries, one can expect little, if any, expansion of the currant industry. Local consumption, for which the South African currant is mainly produced, is not likely to increase greatly and markets of the Northern Hemisphere are already glutted with currants. Greek currants offer great competition in all markets, even in the Far East. Moreover, Australia has become an additional competitor with Union currants. Thus expansion of South African exports in quantity to the best potential markets seems to be out of the question. Moreover, import data indicate that home-grown currants are not replacing imported raisins of the better quality.

Fresh-Grape Outlets.—In general it can be said that the production of fresh fruit for the markets in the Northern Hemisphere offers greater prospects of profit than expansion of the dried-fruit industry. During the last five years exports of fresh grapes to the United Kingdom have almost doubled. The South African grape arrives in London from February to May, and dominates the British market, having practically no competition during that period except from the Belgian hothouse grape. In April and May Argentine grapes come in, and in the future Chilean grapes may compete. Up to the present, however, competition from South America has not been important. It is probable that many

[127] United States exports (compiled from: Foreign Commerce and Navigation of the United States) of raisins to the Union of South Africa in pounds: 1920, 14,488; 1921, 432; 1922, 3,835; 1923, 3,997; 1924, 2,964; 1925, 4,334; 1926, 1,425; 1927, 21,857; 1928, 66,123; 1929, 116,086. Mozambique: 1925, 1,185; 1926, 0; 1927, 98; 1928, 2,226; 1929, 3,973. U. S. Consul Cecil M. P. Cross states that "it should continue to be possible to sell a few specially packed seeded and seedless raisins in South Africa so long as the existing duty on imported dried fruit is not increased."

South African viticulturists will be induced to check raisin production in favor of growing fresh table grapes and other fresh fruit for the markets of the Northern Hemisphere.

There is much land available for dried-fruit production in South Africa but the exact size of these areas is not fully known. The Union, however, needs settlers (in the case of commercial fruit growing) with a fair amount of working capital. Because of the flourishing trade in fresh grapes and also because the prospects of the raisin and currant industry are rather uncertain, no one with capital can be induced to take up raisin production on an extensive scale in the Union. For these reasons one might expect the raisin and currant production in South Africa to do no more than remain stable at about 10 to 12 million pounds annually for many years to come.

GOVERNMENT ASSISTANCE

The South African raisin industry, so far, has enjoyed but few privileges that have not been granted to other branches of agriculture. The bounty paid by the wine producers' organization to encourage the drying of raisin grapes instead of using them for wines has, of course, encouraged drying somewhat. Their Department of Agriculture, of course, lends its scientific help in improving the quality of raisins and currants produced by research and extension and every attempt is being made to place the South African product on an equality with raisins and currants from other countries.[128]

The aim to improve the quality and the reputation of South African raisins has led to the enactment of the Agricultural Produce Export Act of 1917, by which official inspection of dried fruit to be exported has been established. The original act has undergone several amendments, the last of which was dated November 14, 1930. Under this Act export certificates are prescribed. The fruit must fulfill certain requirements as regards cleanliness, grading, and appearance. Packages of raisins which have been bleached must indicate this fact, and all containers must bear the words "Product of the Union of South Africa," besides indicating the registered mark of the exporter, the kind of fruit, and the grade. Within the realm of agricultural economics, legislation regarding coöperation, transportation, and credit is well provided for, but no special attempts have been made to promote the raisin industry by paying premiums or expanding production at government expense.

[128] A United States consular report of August 13, 1926, states that the government has sent a number of students to California to study methods in vogue there and has employed them on their return as experts to advise producers. It also exerts its influence in having the recommendations of these trained men carried into effect.

Some protection of the home market for raisins and currants has been granted as a result of demands presented to the government by farmers' associations, inasmuch as the import duty on all dried fruit, including raisins and currants, was raised on March 30, 1930, from 4½ cents a pound to 6 cents a pound.

THE CHILEAN RAISIN INDUSTRY[129]

In any investigation of the international aspects of raisin growing, Chile must be considered, not so much because of the present size of the industry, but because of the potentialities of the industry. The industry centers in the Huasco district of the Province of Atacama and in the Elqui Valley of the Province of Coquimbo, the latter producing roughly ten times as much as the former. Insignificant quantities are also produced in the provinces of Santiago and Talca. The varieties grown are the Muscat, said to have been brought over by the Spanish conquerors, and a black grape, produced for export purposes because of its better keeping quality.

PRODUCTION TREND

Unfortunately there are no production figures prior to 1909. Moreover, those for the years since then must be accepted with reservations not only because they frequently seem to be out of line with exports, but also because identical production figures are given for a number of years. Tables 52 and 53 give the production and export statistics on Chilean raisins over a period of years. The exceptionally high export figure for 1920 is believed to be fairly correct, which makes it appear

[129] General sources used for this section in addition to those given in specific footnotes:

Bauer, Walter. Government assistance to fruit growing in Chile, 1930. 9 p. (Typed manuscript on file in the Library of the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C. and also in the Giannini Foundation Library, Berkeley, California.)

Bullock, Dillman S. The agricultural situation in Chile. 1923. (Typed manuscript on file in the Library of the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.)

[Chile] Diario Oficial, published daily. Santiago de Chile.

Chile Departamento de Agricultura. Boletín del Departamento de Agricultura, published quarterly. Santiago de Chile.

[Chile] Dirección General de los Servicios Agrícolas, Boletín de los Servicios Agrícolas, published quarterly. Santiago de Chile.

Chile. Laws, Statutes, etc. Boletín de las leyes i de las órdenes i decretos del gobierno, published monthly. Santiago de Chile.

Chilean Review, published quarterly. London.

Jones, Clarence F. South America. 798 p. H. Holt and Co., New York. 1930.

League of Nations. International Economic Conference, 1927. Memorandum on the economic, etc., situation in Chile. Geneva.

Sociedad Nacional de Agricultura, Boletín, published monthly. Santiago de Chile.

that production was greater than indicated in table 52 unless carryover was important in that year. On the basis of the meager and somewhat conflicting information available, one might hazard a guess that normal

TABLE 52

RAISIN PRODUCTION IN CHILE, 1909–1927, 1932

Year harvested	Quantity	Year harvested	Quantity
	1,000 pounds		*1,000 pounds*
1909	1,058	1919	527
1910	1,067	1920	527
1911	1,460	1921	1,295
1912	1,515	1922	1,295
1913	2,190	1923	1,295
1914	1,767	1924	3,802
1915	1,536	1925	3,802
1916	2,260	1926	3,802
1917	2,100	1927	1,800
1918	457	1932	1,700

Sources of data:
1909-1918: Estadistica Agricola.
1919-1927: Anuario Estadistico. Part III (Agriculture).
1932: approximate estimate based on data in Foodstuffs 'Round the World, Canned and Dried Foods **9** (52): 5. 1933.

TABLE 53

RAISIN EXPORTS FROM CHILE, 1899–1932

Calendar year	Quantity	Calendar year	Quantity	Calendar year	Quantity
	1,000 pounds		*1,000 pounds*		*1,000 pounds*
1899	519	1910	268	1921	882
1900	510	1911	184	1922	679
1901	352	1912	214	1923	876
1902	373	1913	253	1924	794
1903	568	1914	294	1925	551
1904	357	1915	730	1926	333
1905	300	1916	597	1927	446
1906	157	1917	379	1928	422
1907	206	1918	205	1929	591
1908	228	1919	792	1930	434
1909	375	1920	1,737	1931	525
				1932	602

Sources of data:
1899-1915: Estadistica Commercial.
1916-1926: Anuario Estadistico. Part XI.
1927-1929: Estadistica Anual. Part VII.
1930: Internatl. Yearbook of Agr. Statis. **1930-31.**
1931-1932: Republica de Chile, Comercio Exterior, and Estadistica Chilena, December issues.

production at present is in the neighborhood of 1,000 tons. Obviously, such a tonnage is unimportant as far as the international raisin situation is concerned.

TRADE POSITION

The strongest demand for Chilean raisins from abroad occurred from 1919 to 1924. This was due to the appearance of the United States as an occasional customer. The American market appeared for the first time

in Chilean export statistics in 1915, but disappeared again in 1926 (table 54). The United States trade statistics do not show any imports of raisins from Chile since that year. In 1920, however, the United States took 82.4 per cent of the total Chilean exports of raisins.

The main Chilean raisin export markets with rather stable demand are the South American countries, Peru, Bolivia, Ecuador, Argentina (in the order of their importance) and Panama. The main European market is the United Kingdom. A few thousand pounds were exported to China and Japan annually in the period 1921–1926 but none since then.

TABLE 54

RAISIN EXPORTS FROM CHILE TO THE UNITED STATES, 1915–1925

Calendar year	Quantity	Calendar year	Quantity
	1,000 pounds		*1,000 pounds*
1915	2	1921	508
1916	51	1922	221
1917	1	1923	145
1918	1	1924	144
1919	37	1925	65
1920	1,431		

Source of data:
Original source unknown, probably from Anuario Estadistico. Part XI.

FUTURE PROSPECTS

Chile is often called the California of South America. The climatic and soil conditions, especially in middle Chile, make large areas admirably suited to fruit production. Moreover, the distance to European markets via the Panama Canal is about the same as that of California. One would think that, with the gradual removal of transportation handicaps, the raisin industry would have expanded, since large areas appear to be suitable for vine cultivation. But the country has not developed this industry to the same extent as California, partly because it has not had the same rich and enormous hinterland to take its product.

On account of reverse seasons, Chile is able to supply fresh grapes to important consuming markets at times when the Northern Hemisphere is not in production. For that reason, the fresh grape is the chief competitor of raisins for the use of fruit land in Chile. The tendency towards concentrating on fresh-grape production is supported by the fact that the grape from Huasco and Elqui is seeded, although the seeds are comparatively small. The demand for loose raisins with the seeds in them is diminishing throughout the world and the demand for clusters is amply supplied largely by Spain.

If Chile, therefore, should attempt to expand the raisin industry, it logically would plant seedless varieties. In view of the thoroughly supplied world consumption of seedless varieties and the competitive struggle, which already involves all of the currant and sultana raisin-growing countries, any further expansion can hardly be recommended to a country whose raisin industry is not already on a firmly established basis. It is also doubted whether the South American countries, in which dried-fruit consumption is allegedly low on account of the abundance of fresh fruit, will increase their demand, with the possible exception of Argentina. The latter country, however, would probably prefer to foster home production than to import raisins and currants from Chile.

In general it is believed that it would pay better in Chile to plant land which could be used for raisin production with trees and vines for fresh fruit production for the winter and spring markets in the Northern Hemisphere when their supply of fresh fruits is most limited and expensive.

GOVERNMENT ASSISTANCE

A review of agricultural legislation in Chile does not reveal any special measures taken on behalf of raisin growing, and with prospects for low raisin prices normally for several years, the industry will probably not expand much without governmental assistance. The fruit-growing promotion law of November 8, 1928, provided, however, for a state-operated model plant in central Chile on a commercial scale for cleaning, grading, and packing all kinds of fresh and dried fruits. Such a packing plant equipped with machinery for stemming, grading, and packing raisins was opened by the Chilean government in 1932 in connection with its Horticulture Experiment Station at Vicuna in the Elqui Valley, near the center of the chief raisin-producing section in Chile. The plant is operated in conjunction with the coöperative Elqui-Hurtado, Ltda., an association comprising about 80 per cent of the fruit growers of that section of the country. A number of measures have been enacted in connection with this law, such as plant protection, coöperation, transportation, fruit inspection, etc., but these items have no essential bearing on the economic expansion of the raisin industry. Toward the end of 1930, the government formed a special board for the promotion of agricultural exports. It may be that this board will develop some activity on behalf of the raisin industry.

THE ARGENTINE RAISIN INDUSTRY[130]

Argentina is a raisin-importing country, the average net raisin imports (1925–1929) amounting to 1,669,000 pounds annually. Raisins, however, are also grown in Argentina itself and a few are exported.[131] The industry centers in the region known as the "Cuyo," which stretches along the cordillera of the Andes for a distance of about 600 miles. The two main varieties produced are both Muscats—the Moscatel blanco (white) de San Juan and the Moscatel rosado (red or rose) de Mendoza.

PRODUCTION TREND

As there are no official statistics either on raisin acreage or production, it is necessary to estimate the approximate volume of the industry. According to data given in a 1927 publication of the Buenos Aires Pacific Railroad,[132] the following quantities of raisins are usually produced in the provinces belonging to the "Cuyo."

Production in the "Cuyo":	In thousands of pounds
Province of San Juan	3,307
Province of La Rioja Province of Catamarca	1,102
Imports into Argentina	1,102
Total consumption	5,511

In this statement, the raisin production of the Province of Mendoza, which is mainly a wine and prune-producing region, is not mentioned. The Mendoza production, because of its relatively small size, was probably included in the figure for San Juan. This same publication reports that the annual per-capita consumption of raisins in Argentina amounts

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[130] General sources used for this section in addition to those given in specific footnotes:

[Argentine Republic] Boletín oficial, published daily. Buenos Aires.

Argentine Republic. Laws, Statutes, etc. Leyes Nacionales. Buenos Aires.

[Argentine Republic] Ministerio de Agricultura. Boletín, published quarterly. Buenos Aires.

Estabrook, Leon M. Agricultural survey of South America: Argentina and Paraguay. U. S. Dept. Agr. Dept. Bul. 1409:1–32. 1926.

Ferro Carril de Buenos Aires al Pacifico. Rivista mensual. Buenos Aires.

Lafond, G. La République Argentine. 96 p. Pierre Roger, Paris. 1927.

Mendoza, Argentine Republic (Province). Laws, Statutes, etc. Leyes usuales de la Provincia de Mendoza. Mendoza.

San Juan, Argentine Republic (Province). Boletín oficial de la Provincia de San Juan. San Juan.

[131] Exports of raisins from Argentina during the ten years 1920–1929 averaged 100,000 pounds annually, mostly to nearby South American countries, from: Internatl. Yearbook Agr. Statis.

[132] Ferro Carril de Buenos Aires al Pacifico. "Mas y major fruta seca nacional." ["More and better national dried fruit."] Folleto No. 15. 1927.

to about 0.5 pound. The population at that time (1926) was estimated at 10,300,000 inhabitants. At 0.5 pound per capita the present population of about 12,000,000 would consume approximately 6,000,000 pounds. Net imports during the years 1928 and 1929 were 2,257,320 pounds and 2,035,755, respectively, which would leave a difference of roughly 4,000,000 pounds to be supplied by home production.

It is believed that the above mentioned production figure, calculated by the railroad company, is approximately correct, although early preliminary estimates indicate that the 1933 raisin crop of the Province of San Juan amounted to about 5,000,000 pounds. It is also believed that any increase in total consumption, which may have been brought about by increasing population, has not been taken care of by a corresponding expansion in the home industry but by increasing imports. It must not be forgotten that Argentina produces seeded raisins almost exclusively. The increasing imports consist of seedless currants and especially sultana raisins which undoubtedly are preferred.[133] On the other hand, the net exports of fresh grapes from Argentina had about doubled during 1928 and 1929 in comparison with former years. Apparently it is more profitable to ship the grapes fresh than to make them into raisins.

PROSPECTS FOR EXPANSION

The raisin situation in Argentina is similar to that in Chile. Argentina also has the advantage of having seasons the reverse of those of the Northern Hemisphere but has the disadvantage of producing seeded raisins for which there is no demand. The limited population, the possibilities of producing fresh fruit for both the domestic and foreign markets, and the relatively small consumption of dried fruit in Argentina itself, are factors which stand in the way of expansion of the dried-fruit industry. Unless seedless varieties are used for raisin production, the industry cannot hope to expand. Doubtless there are a great many acres available for sultana plantations, and climate and soil conditions are extremely favorable to the development of this industry. It can hardly be assumed, however, that under present conditions in the world market for raisins and currants the cultivation of sultanas would be profitable in Argentina. The suggestion has been made that sultanas should be planted in order to replace at least the imports coming from California.

[133] Imports of sultanas from the United States amounted to about 750,000 pounds in 1927 (according to Anuario del Comercio Exterior). Exports to Argentina from the United States were 1,789,152 pounds in 1928, and 1,362,929 in 1929 (according to Foreign Commerce and Navigation of the United States).

The 1933 estimate of San Juan production is from: Foodstuffs 'Round the World. Canned and Dried Foods 9(60):5. 1933.

Whether the Argentina grower will be able to compete with the California grower on the Argentine market will depend on tariff policy, government support, and cost of production.

ASSISTANCE TO THE INDUSTRY

Three agencies actively interested in the promotion of the raisin industry are in existence in Argentina, i.e., the national government in Buenos Aires, the provincial governments, and the administration of the Buenos Aires Pacific Railroad, which is particularly interested in developing the "Cuyo" region.

Government Activities.—The national government has enacted legislation for the encouragement of agriculture, but little of significance has been done for the raisin industry. In 1919, a National Mortgage Bank was created, which is empowered to make loans on vineyards up to 50 per cent of their value. In case of losses of fruit or plants and of diseases attacking the plantation, amounting to more than 30 per cent of the crop or acreage, this bank can compel the owner to replant immediately. In 1922 and 1924 an inspection of products to be exported was established. This was combined in 1923 with the obligation to apply a national trade-mark called "Industria Argentina." This is still without significance to the raisin trade since very few raisins are exported. A customs law of 1923 exempts fertilizers, machinery, and live plants from import duties. Another law grants credits to the national government for the purchase of plants with a view to encouraging agriculture. In 1926 the National Bank of Argentina was authorized to make loans to coöperative societies for the acquisition of land and the construction of establishments for the industrialization of home-grown produce. Nothing is known concerning the extent to which these financial facilities have been utilized by the raisin growers. A new plant-protection service was established in 1926 for all fruit-growing regions. In 1927 a special office for the regulation, inspection, and encouragement of coöperatives was created. In regard to the provincial governments, there is no information to indicate that anything has been done by special legislative measures.

Buenos Aires Pacific Railroad Activities.—The administration of the Buenos Aires Pacific Railroad, on the other hand, has been encouraging the development of the sultana raisin industry and has been laying great stress upon the necessity of using machinery of the kind employed in California for the processing of raisins. It has established two experiment stations and an extension service to give advice on all phases of raisin and currant production and the use of machinery. This railroad

has also been trying to bring about concerted action between producers, merchants, and the governments in order to promote the dried-fruit industry. Among other things, it advocates the establishment of a protective tariff during the period needed by the industry to develop to the desired size. Moreover, it maintains that the provincial governments should adopt the following measures: (1) grant special privileges to dried-fruit producers, and exempt them from taxes for five years; (2) introduce machinery for processing, and conduct demonstrations; (3) build up an adequate and intelligent extension service.

If the national government adopts a paternalistic attitude toward the raisin industry, by means of high protective tariffs, and if the provincial governments carry on a promotion scheme, imports could be curtailed and consumption of Argentine raisins presumably expanded somewhat.

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THE ALFALFA WEEVIL

E. O. ESSIG AND A. E. MICHELBACHER

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THE ALFALFA WEEVIL[1]

E. O. ESSIG[2] AND A. E. MICHELBACHER[3]

INTRODUCTION

The alfalfa weevil was discovered in the commercial alfalfa-growing districts of middle California on May 13, 1932, by R. A. Blanchard, of the United States Department of Agriculture. Its presence here may become a matter of importance to this state. Although it was known to occur in certain alfalfa fields in the northeastern part of the state, the intervening high Sierra Nevada was considered a sufficient barrier to restrict its natural spread into the interior valleys and coastal regions. To prevent the artificial spread of this and other insects over the mountains and across state lines, the State Department of Agriculture has maintained a border inspection service on all interstate highways. Yet in spite of all attempts to exclude it, the alfalfa weevil now occurs in six adjacent counties in the San Francisco Bay region and the extreme northern San Joaquin Valley.

Information concerning the life history and economics of the pest is largely based on its activities in infested areas in the Great Basin region of the United States. The climate in California is very different from that of other infested places in this country, and it is expected therefore that the insect will respond in an entirely different manner in this state. In fact, it is believed that its behavior here will be more likely to parallel that in southern Europe, whence the weevil was introduced into the Great Basin. In the latter region alfalfa is commercially grown at an elevation of from 2,000 to 6,000 feet whereas in California this crop is produced generally at elevations less than 100 feet, although considerable amounts are grown above 500 feet and some even above 1,500 feet altitude.

As an aid in dealing with the insect in this new lowland area on the Pacific Coast, it has seemed advisable to review most of the literature treating the insect in both the Old and New Worlds. So many illuminating facts have thus been gleaned that it has been decided to summarize them in bulletin form for the benefit of all who may be interested in or held responsible for the study and control of the alfalfa weevil in California.

[1] Received for publication May 29, 1933.

[2] Professor of Entomology and Entomologist in the Experiment Station.

[3] Research Assistant in Entomology.

It has been our purpose to assemble the most important facts as direct quotations or to give the substance of them together with the references to the different authorities who have studied this insect in various parts of the world, so that there can be no mistakes in our attempted interpretation of the meaning of the authors. Naturally there are many statements which appear to be contradictory, but in nearly every such case the facts show that the apparent discrepancies are due to differences in climate, agricultural practices, the methods employed by the investigators, or some other factor.

SYSTEMATIC POSITION

According to the best authorities at this time the correct scientific name of the alfalfa weevil is *Phytonomus variabilis* (Herbst),[4] by which name, or as *Hypera variabilis* (Herbst), it has been known in Europe for a number of years (Joy, 1932).[5] In North America the names *Phytonomus posticus* (Gyllenhal) (Titus, 1911) and *Hypera postica* (Gyllenhal) (Essig, 1931) have been used up to this date.

The insect was first referred to in literature as *Curculio haemorrhoidalis* by Herbst in 1784 (Herbst, 1784), who subsequently described it as a new species, *Curculio variabilis* in 1795 (Herbst, 1795). Gyllenhal did not publish his description of *Phytonomus posticus* until 1810 (Gyllenhal, 1810), so this latter name must give way to the older one by Herbst.

Its wide natural distribution, climatic range, and variable coloration have resulted in much confusion in identifying the species and have given rise to many conflicting ideas concerning its exact systematic status. Some idea of the many names by which it has been known by various writers may be gained from the study made by Titus in 1911 (Titus, 1911). He lists 50 different aberrations, varieties, and species, and 6 different genera, together with 264 separate citations. Since then many additional references are to be found, chiefly in economic literature.

OLD-WORLD DISTRIBUTION

According to Titus (1911) the alfalfa weevil has a wide distribution in the Old World and occurs wherever alfalfa and other host plants are grown throughout Europe, excepting only the northernmost limits of Norway, Sweden, Finland, and Russia; in western central Asia, including southwestern Siberia, all of Turkestan, Persia, Arabia, Asia Minor,

[4] See Joy (1932).

[5] See "Selected Bibliography" for complete data on citations, which are referred to in the text by author and date of publication.



Fig. 1.—Map showing the approximate world distribution of the alfalfa weevil as known in 1932. (Outline map adapted from Goode's series of base maps and graphs No. 101 HC, by permission of the University of Chicago Press.)

and an area in Bengal, India; the north coast of Africa; and the Madeira and Canary Islands (fig. 1). It appears, however, to be most important as an economic pest in the more temperate sections of this vast area. A review of the economic literature dealing with this pest published since 1912 indicates that the insect has been observed in the following countries:

Bulgaria (Chorbadzhiev, 1931)
Denmark (Lind, Rostrup, and Kølpin Ravn, 1917; Ferdinandsen and Rostrup, 1921.
France (Picard, 1914*a*; Marchal and Foex, 1921; Grassé, 1929)
Germany (Lüstner, 1923; Molz and Müller, 1929)
Great Britain (Joy, 1932)
Italy (Martelli, 1911)
Morocco (De Lépiney and Mimeur, 1932)
Poland (Woroniecka, 1924; Krasucki, 1925)
Russian Socialist Soviet Republics:
Kuban (Grossheim, 1913; Uvarov, 1917)
Ukarine (Vassiliér, 1913; Kolobova, 1929)
Turkestan (Smirnov, 1913; Plotnikov, 1914; Dvornitchenko, 1917; Yakhontov, 1929, 1931; Kharin, 1930)
Spain (Spain, 1929; Benlloch, 1930)
Sweden (rarely) (Tullgren, 1917)
India: Pusa, Bengal (G. A. K. Marshall, 1913)

SPREAD IN THE UNITED STATES

Some idea of the extensiveness and the rapidity of the spread of this weevil in the United States (fig. 2) may be gained from the following tabulations:

1904.
Utah: The earliest record obtainable indicates that it was first noted on a farm on the east side of Salt Lake City in the spring of 1904 (Titus, 1910*a*).

1905.
Utah: Damage noticed in alfalfa fields several miles southeast of the 1904 infestations (Titus, 1910*a*).

1906.
Utah: Weevil found on northeast side of Murray (Titus, 1910*a*).

1907.
Utah: By the fall of 1907 the weevil had spread as far south as Big Cottonwood Creek, thus covering the alfalfa territory east of Salt Lake City and Murray (Titus, 1910*a*).

1908.
Utah: Infestation reached Sandy, West Jordan, Granger, Midvale, and Taylorsville (Titus, 1910*a*).

1909.
Utah: Almost 100 square miles of territory infested, comprising about 2,500 acres of alfalfa (Titus, 1909*b*); probably reached all parts of Salt Lake County, and as far north as Centerville in Davis County; also known to have been present in parts of Summit County, along the Weber River, for at least three years (Titus, 1910*a*).

1910.

Utah: New infested area July 1: Morgan, Weber, Tooele, Utah, and Wasatch counties and found at from 4,200 to 7,500 feet in altitude (Titus, 1910*a*, 1910*b*).

1911.

Idaho, Utah, Wyoming: By September, 1911, the insect had extended its area of diffusion directly northward as far as Tremonton, Utah, east to Evanston, Almy, and Lyman, and northeast to Cokeville, Wyoming; Randolph, and Laketown, Utah; and Fish Haven, Idaho (Webster, 1912).

1912.

Utah: Parts of Box Elder, Cache, Rich, Sanpete, Millard, and Juab counties.

Wyoming: Uinta County (Titus, 1913).

1913.

Idaho: In small numbers in Oneida, Franklin, and Bear Lake counties. Infestation extended over an area approximately 180 miles long by 90 miles wide (Parks, 1913).

1916.

Idaho: Cassia County.

Utah: Carbon County.

Wyoming: Lincoln and Sweetwater counties (Reeves, Miles, *et al.*, 1916).

1917.

Colorado: First infestation discovered near Paonia, in the upper part of the North Fork Valley, Delta County (Gillette and List, 1919).

1918.

Colorado: Gunnison County (List and Wakeland, 1919).

1919.

Colorado: Montrose County (Wakeland, 1920).

Oregon: About the time the alfalfa weevil first appeared (Fulton, 1921).

1920.

Nevada: Weevil first discovered outside of Reno, Washoe County, in June (Nevada Agricultural Experiment Station, 1921).

1921.

Idaho: Infestation increased from 15 to 21 counties (Idaho Agricultural Experiment Station, 1921); Gooding County (Wakeland and Whelan, 1922*b*).
Fremont County (Montana Agricultural Experiment Station, 1921).

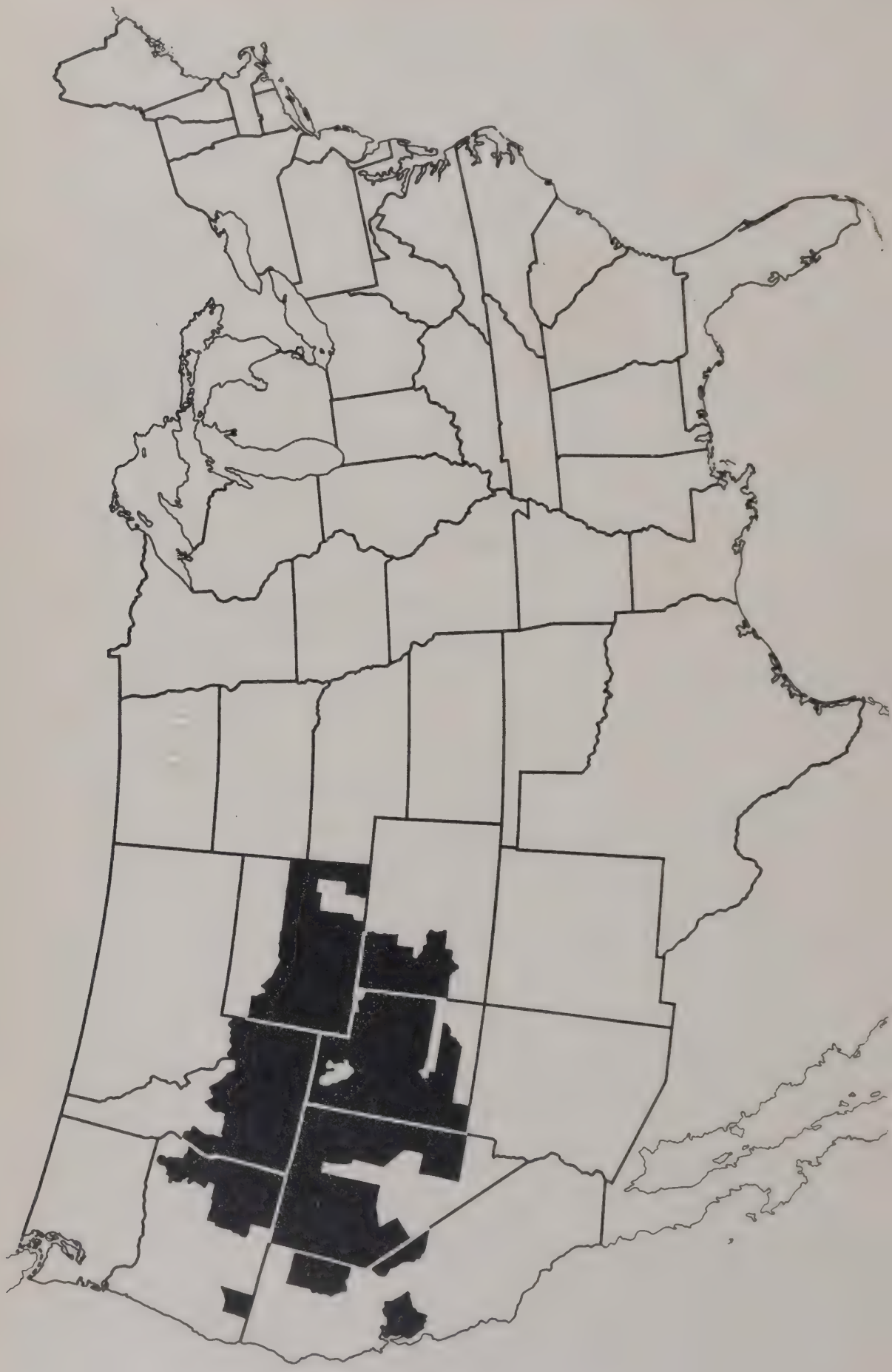
Nevada: Weevils present in all alfalfa fields lying north of the Truckee River from a point about 2 miles northwest of Reno to a point 5 miles east of the city (Nevada Agricultural Experiment Station, 1921).
White Pine County (Creel, 1922; Snow, 1925).

1922.

Idaho: Just established in Canyon County (Wakeland and Whelan, 1922*a*).

Nevada: Lovelock, Pershing County (Snow, 1925; Creel, 1922).
Washoe County (Creel, 1922).

Oregon: "Besides Malheur County, which was the only one infested last year, Baker County has been added as the weevil was found at Durkee, Oregon" (Wakeland and Whelan, 1922*b*).



1923.

California: Just across the boundary near Verdi, Nevada, July 6 (California State Department of Agriculture, 1923); found in Sierra County just across the Nevada boundary (Snow, 1925).



Fig. 3.—Approximate areas infested by the alfalfa weevil in 1932.

1924.

Nevada: At Fernley and Hazen, on the Swingle Bench, and at Dayton (Snow, 1925).

1925.

California: Plumas and Lassen counties (Urbahns, 1925).

Wyoming: Fremont, Natrona, and Converse counties. "This is the first known infestation of this insect on the eastern slope of the Rocky Mountains, and places this pest at the back door of the Mississippi Valley. It is not doing damage here yet" (Corkins, 1925).

1926.

Colorado: Weevil discovered for the first time in portions of Rio Blanco, Routt, and Ouray counties; probably extension of the infested area in southwest Wyoming (Gillette, 1927); Moffat County (Reeves 1927*a*).



Fig. 4.—Distribution of alfalfa culture in 1930. (From Bul. 521.)

Idaho: Ada, Bannock, Bingham, Blaine, Bonneville, Butte, Camas, Jefferson, Jerome, Lincoln, Madison, Minidoka, Owyhee, Payette, Power, Twin Falls, Washington, Caribou, Clark, Custer, Elmore, and Gem counties (Reeves, 1927*a*).

Nevada: Weevil found in Mineral and Lyon counties for first time (Fleury, 1926); Churchill, Pershing, Storey, and Washoe counties (Reeves, 1927*a*).

Oregon: Union County added to list (Reeves, 1927*a*).

Utah: Beaver, Duchesne, Emery, Iron, Piute, Sevier, Uintah, and Washington counties (Reeves, 1927*a*).

Wyoming: Goshen and Carbon counties, near the Nebraska state line (Hyslop, 1926); Converse, Fremont, Laramie, and Natrona counties (Reeves, 1927*a*).

1927.

Nevada: Douglas County; a new infestation (Reeves, 1927*c*).

Wyoming: Niobrara County, a new infestation (Reeves, 1927*c*).

The alfalfa weevil has advanced from about 40 miles west of the Nebraska-Wyoming line to about 8 miles west of that line (Swenk, 1927).

1928.

Colorado: Discovered in Mesa and Garfield counties (Reeves, 1928).

Idaho: Discovered in Adams and Boise counties (Reeves, 1928).

Nevada: A recent find in Lincoln, Humboldt, and Elko counties (Reeves, 1928).

Nebraska: Record based on finding of a single larva; Scott's Bluff County was erroneously cited for Sioux County (United States Department of Agriculture Bureau of Entomology, 1929; Reeves, 1928).

Utah: Garfield County; a recent discovery (Reeves, 1928).

1929.

California: Alpine County, a new area; weevil spreading slowly in Lassen County east of the Sierra Nevada (Fleury, 1932*a*, p. 56).

Oregon: Jackson County a new infestation; no weevil noted so far that year in Union County (Cole, 1932, p. 60); found in Medford, Jackson County, in western Oregon (United States Department of Agriculture Bureau of Entomology, 1929).

Utah: Grand County, previously thought to be uninfested (F. E. Stephens, 1932; United States Department of Agriculture Bureau of Entomology, 1929).

1930.

Idaho: Ada, Bingham, Blaine, Bannock, Butte, Camas, Custer, Caribou, Clark, Elmore, Gem, Jefferson, Jerome, Lincoln, Madison, Minidoka, Payette, Power, Teton, Twin Falls, and Washington counties (Wakeland, 1930).

Wyoming: Southern two-thirds of the state under quarantine, but the pest had not reached the northern part of the state (F. E. Stephens, 1932, p. 118).

1932.

California: New infestations in Stanislaus, San Joaquin, Alameda, Santa Clara, and Contra Costa counties (Fleury, 1932*b*); a new very light infestation found near Coleville, Mono County (California State Department of Agriculture, 1932*a*).

Nevada: Ormsby and Lander counties added.[6]

1933.

California: Merced County.

[6] Reeves, G. I. Personal correspondence.

Summary of Distribution by States and Counties[7]

California: Alameda, Alpine, Contra Costa, Lassen, Mono, Merced, Plumas, San Joaquin, Santa Clara, Sierra, Stanislaus.

Colorado: Delta, Garfield, Gunnison, Mesa, Moffat, Ouray, Rio Blanco, Routt.

Idaho: Ada, Adams, Bannock, Bear Lake, Bingham, Blaine, Boise, Bonneville, Butte, Camas, Canyon, Caribou, Cassia, Clark, Custer, Elmore, Franklin, Fremont, Gem, Gooding, Jefferson, Jerome, Lincoln, Madison, Minidoka, Oneida, Owyhee, Payette, Power, Teton, Twin Falls, Washington.

Nevada: Churchill, Douglas, Elko, Humboldt, Lander, Lincoln, Lyon, Mineral, Ormsby, Pershing, Storey, Washoe, White Pine.

Oregon: Baker, Harney, Jackson, Malheur, Union.

Utah: Beaver, Box Elder, Cache, Carbon, Davis, Duchesne, Emery, Garfield, Grand, Iron, Juab, Millard, Morgan, Piute, Rich, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Washington, Wasatch, Weber.

Wyoming: Carbon, Converse, Fremont, Goshen, Laramie, Lincoln, Natrona, Niobrara, and Uinta.

DESCRIPTION AND LIFE HISTORY

ADULTS

The adult beetles (fig. 5) are described by Titus (1909*b*) as varying from $\frac{3}{20}$ in. long in the male to $\frac{1}{4}$ in. in the female. When freshly emerged they are brown with a distinct darker line extending centrally down the elytra. The head and pronotum are finely and closely pubescent with short gray hair, that on the head sometimes extending quite to the tip of the beak. The prothorax is slightly longer than wide, narrower in front than behind, widest in the middle, rounded on the sides and densely, finely punctured. There are two longitudinal stripes of fine brown scales, separated in the middle by a narrow gray line; the sides of the prothorax are covered with dense gray hairs. Elytra or wing covers are one-third wider than the prothorax, oval, but with sides nearly parallel, humeri rounded; the striae are distinctly punctured. The elytra have rows of fine gray setae alternating with hair-like scales, each being deeply cleft so that it appears as two hairs; and some fine darker hairs are present in such a manner as to present small spots of black. Antennae have the first funicle joint much longer than the second; last joint of the funicle is separated from club. Legs are dark brown with numerous gray hairs on the femora and tibiae; tarsi more sparsely pubescent. Antennae are slightly pubescent. The males are slightly narrower than the females.

[7] Some of these counties are only partially infested by the alfalfa weevil.

In the fields the two sexes are about equally divided as to numbers (Reeves, 1927*b*).

The brown color of the young beetles usually becomes darker as time passes, due to the rubbing-off or shedding of the scales and the darkening of the cuticula (Snow, 1928). Old adults sometimes become almost black, and this darker color helps to distinguish them from the new generation in late spring and summer. According to Snow (1928) the

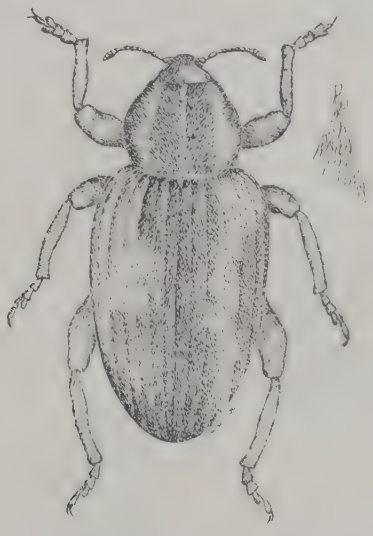


Fig. 5.—The alfalfa weevil, *Phytonomus variabilis* (Herbst). Adult and enlargement of scales which cover the body. (From *A History of Entomology,* Macmillan Co. Reproduced by permission of the copyright owners.)

period in which the two generations overlap is from May to October, and he calls attention to the fact that the difference in color "is not always marked enough to be a reliable means of separation. The change in color from light brown to dark brown does not all take place during the winter, as reported in early studies of the weevil, but chiefly later on near the beginning of summer; and even in the late summer old beetles are occasionally found with the scales not entirely removed and the color not distinctly dark."

According to Titus (1910*b*) the length of life of the adult cannot be definitely stated, but weevils were kept from the time they emerged in May for eighteen months. But according to the accumulated data the life of the adult is from ten to fourteen months, and in general the beetles which survive the winter die off rather rapidly after the egg-laying period is completed the following spring.

In the early spring after the hibernating adults become active they may do considerable damage to the alfalfa, which is just starting to

grow, by feeding on the young shoots. In some fields examined Titus (1910*a*) reported that over 30 per cent of the spring growth had been killed back by feeding punctures; the severity of the results was due to the fact that the plants were so small at the time injury was done that there was not room enough left for the sap to pass up the stems to maintain the growth. Other investigators also report the adults as feeding



Fig. 6.—The clover leaf weevil, *Phytonomus punctatus* (Fabr.) (*Hypera punctata*), a common insect in alfalfa fields often confused with the alfalfa weevil. (From *Insects of Western North America*, Macmillan Co. Reproduced by permission of the copyright owners.)

rather freely for several weeks in early spring when the plants are small, and under such conditions they often do considerable damage.

Wakeland (1924) cites instances where newly emerged adults, as well as larvae, have retarded development of the second crop and also observes that they have been known to kill young stands of alfalfa by migrating from a recently cut field to an adjoining new stand and eating the plants before the roots became established. Titus (1910*a*) has also pointed out that where large numbers of adults occur in a field, considerable damage may be done to the second crop, and sometimes even to an early third crop of alfalfa. The spring feeding habits of the weevils consist in making punctures in the stalks, whereas in the later feedings, on the second and third crops, they rasp the epidermis from the stalk and slit the leaves into ribbons (Titus, 1910*b*)

The majority of the weevils feed on the leaves at night from 9 P.M. to 1 A.M., and many of them are partly concealed on the plant and again feed about daylight. After this they go down to the ground and many stay hidden until dark, while others feed some during the day on the stalks and the leaves of the plant. Reeves, Miles, *et al.* (1916) report that the weevils stay close to the ground during early spring and late fall; and that at the time of cutting the second crop the fields are full of weevils of the new generation. Hay of the second crop contains many more adults than that of the first or third crop. The adults are more active by night than by day during the summer, and this condition continues until the cool weather of September sets in. As fall approaches they frequent the plants less and less.

When feeding on the plants they readily drop to the ground upon the slightest disturbance, and because of this habit they are not readily seen in the fields. In the San Francisco Bay area of California opportunities for observing the habits of the adults have been few. However, during the first half of June, 1932, on warm quiet days towards noon a fair number of the adults could be observed feeding on the terminal growth in fields which had the heaviest infestation. During the mornings on such days the weevils could be found at the base of the plant, and upon being disturbed, many at least would crawl away, rather than remain motionless as is so often reported. As yet no observations have been made in California as to the night activity of the adults, but an investigation on this point is planned. Although the adults feed throughout the year, the damage caused by them, when compared to that of the larvae, amounts to very little.

Titus (1910*a*) reports that there are repeated periods of mating, and that the males often accompany the females during oviposition; and Parks (1914) states that copulation continues all during the oviposition period. In our observations the beetles have been noted to mate throughout the spring, summer, and fall. Whether these are of the old or new generations, or both, is not known. Dark-colored adults have been observed mating with light-colored individuals, which might indicate that there is mating between the old and new generation, but the difference in color is not always marked enough to be a reliable means of separating the newly emerged from the hibernating forms. However, Titus (1910*b*) reports that copulation has been noticed between newly emerged males and females of the previous year in early July, and that the mating of overwintering forms appears to be continuous from spring to fall.

According to Reeves (1927*b*), the alfalfa weevil has no definite period of hibernation. The adults are quiet when they are cold and active when

TABLE 1

EGG-LAYING HABITS OF THE ALFALFA WEEVIL

Investigator	Area	Where eggs are first deposited in the early spring	Where eggs are deposited later in the year	Period when eggs are most numerous
Titus (1909*b*)	Utah	.....	On the plants and most of those found near the growing tips	.....
Titus (1910*a*)	Utah	On stems, or through the base of the leaves into the young growing buds or even directly on or in the terminal buds	Majority of eggs laid in stems	April-June
Titus (1910*b*)	Utah	Single on the plant, in the buds, axils of the leaves, on the stalk, or beneath the leaf sheath	In the stalks	
Webster (1912)	Utah	A few on outside of plants. Occurs mostly when growings stems of alfalfa are too small or not sufficiently numerous	In the stalks	May-June
Parks (1913)	Idaho	Placed in the stems	Placed in the stems	April-June
Titus (1913)	Utah	On stems and buds, even dropped on the ground or around the plants	Placed in the stems	April-June
Parks (1914)	Idaho	In dead stems of the previous season's growth which are lying on the ground. Later a few placed in green weeds and grass stems	Placed in the stems	May
Reeves, Miles, *et al.* (1916)	Utah and other states	Dry and dead stems on the ground	Placed in the stems; a few eggs on outside of plants, and more in weeds and grasses	May-June
Reeves (1917)	Utah	Dead stems which litter the ground weeks before spring growth of plants starts	Placed in the stems	May
List and Wakeland (1919)	Colorado	In dead grass stems (not alfalfa stems)	Placed in the stems	.....
Reeves, Chamberlin, *et al.* (1920)	Utah and other states	Soft dead stems on the ground	Placed in the stems	May
Wakeland (1924)	Idaho	Dead grass stems scattered on the ground	Later in the season many are laid in green alfalfa stems; apparently a greater proportion is deposited in dry stems throughout the season in lower, warmer localities than in higher, cooler ones	May
Snow (1925)	Nevada	In green stems and in the dry grass and alfalfa stems on the ground	.....	May
Reeves (1927*b*)	Utah and other states	Dry stems on the ground	Placed in stems	April-May
Sweetman (1929)	Wyoming	.....	Most eggs (about 90%) deposited in the stems near the crown; stems in the field showed that 93% of the egg clusters were placed in green stems, 6% in dead standing stems, and 1% in dead fallen stems	May

they are warm. When cold weather approaches the adult weevils creep down close to the ground and into crevices and spend the winter there. Ditch banks and other uncultivated places, which are strewn with litter of dead vegetation, often harbor many of them, but their numbers in these situations are insignificant compared with those which remain in the fields. List and Wakeland (1919) also noted that on warm days in winter the beetles were found active in fields where the snow had melted. Titus (1910*a*) reported the significant fact that from 75 to 80 per cent of the weevils going into hibernation survived the winters of Utah.

EGG-LAYING HABITS

According to most investigators egg-laying begins as soon as warm weather sets in, early in the spring. Usually the first eggs are laid in dead stems, but as the season progresses they are laid mostly in the green alfalfa stems. Generally at first only a few eggs are laid here and there but when the continued warm weather starts egg-laying begins in earnest. To review all that the different investigators have to report on egg-laying would take a considerable amount of space, and as most workers are in fair agreement as to the egg-laying habits, the data have been summarized in table 1.

EGGS

The eggs (fig. 7) of the alfalfa weevil are small, oval, and yellow or orange-yellow in color. To the unaided eye they appear smooth and shiny, but under a microscope the surface of the egg appears very slightly roughened and sculptured. However, a few days after incubation the color of the egg becomes dingy, and towards the latter part of the incubation period the head of the larva shows through the shell as a black spot.

The most probable explanation for the laying of the early eggs in dead stems is the lack of suitable green stems for egg deposition. That female beetles show preference for a certain type of stem is indicated by the investigations of Sweetman (1929), who says: "Apparently the ease with which the stems can be penetrated together with ample space for the eggs within the hollow portions of the stems are important factors influencing the location of places for oviposition. This condition seems to be found most often in the medium-sized stems. Also, the females may find the stems of this size easier to cling to while ovipositing than those of larger or smaller diameter." In this connection he also found that medium-sized stems were used twice as often as the large stems and

three times as often as the small ones, and that a great many of the small stems had no hollow interiors. Webster (1912) reports that tall stems which have made a rapid growth are the ones chosen by the insect for egg-laying. He adds that shorter woodier stems seem seldom to be selected for this purpose.

The adult weevil makes two kinds of punctures, one for feeding, and the other for egg-laying. Feeding holes are easily recognized by their



Fig. 7.—Eggs of the alfalfa weevil deposited in the stem of an alfalfa plant. A portion of the stem has been removed to expose the eggs which were inserted through a small, obscure puncture. Greatly enlarged. (Photo by Matthews.)

irregularity in outline, while egg punctures are generally very much smaller, circular, and smooth. The female makes the egg punctures with her snout, and the process according to Titus (1910*b*) consists in making but one cut with the beak while standing lengthwise of the stem, head downward, the beak being inserted at an angle slightly toward the base of the stalk and given a steady pull up and in, thus making an elongated slit inside the stem, both below and above the puncture. The beak was then withdrawn and the insect either turned around or walked forward and pushed her ovipositor into the puncture. Thirty seconds to 2 minutes are required to lay an egg, and according to Titus (1910*a*) the ovipositor is apparently withdrawn after each egg is laid, but Webster (1912) reports that a number of eggs are laid before the ovipositor is removed from the cavity. Parks (1914) noted that 1 to 4 minutes

elapse between the passage of each through the ovipositor. When a large number of eggs are laid the last one often fills the entrance to the puncture. If this does not occur the female is likely to seal the opening with a secretion. These sealed punctures are easily seen as small dark spots, when alfalfa stems are closely examined. The reason for sealing the punctures is probably to protect the eggs from other organisms, or from drying. That drying is an important consideration is suggested by Sweetman (1932), whose work indicates that low humidities of 50 per cent or less for a few hours during the day are sufficient to kill many of the embryos and that the normal moisture content in the green stems where the eggs are usually laid is probably high enough so that the eggs ordinarily would not be exposed to such low humidities. In a more recent paper Sweetman and Wedemeyer (1933) report the favorable range of temperature for the hatching of the eggs to be between 68° and 86° F with relative humidities of 55 to 95 per cent. Temperatures of 89.6° to 93.2° F were unfavorable for hatching of the eggs, but the length of the incubation period was much shortened; higher temperatures destroyed the embryos.

In regard to incubation period, number of eggs per female, etc., considerable data have been obtained. A portion of this information has been tabulated in table 2. As would be expected there is much variation in the figures. Most of this can probably be accounted for by the different conditions under which the work was performed, and also by the fact that some of the figures are supposed to be only estimates. In the case of incubation period the large deviations might well be taken to denote what might be expected under different temperature conditions.

That the incubation period may be longer than that shown in the table is evident from the work of Reeves, Miles, *et al.* (1916) which showed that eggs laid in the fall did not hatch before the following spring. This same condition of eggs passing through winter is also pointed out by Reeves (1927*b*) and Snow (1925), and even as early as 1912 Webster suspected that in Utah some eggs might survive the winter. Therefore, it is easily seen that where eggs pass through the winter in a living condition the incubation period is of necessity very long.

In this connection it should be stated that there is some evidence that eggs may be winter-killed in areas of low temperatures as in the Great Basin. Titus (1913) states that "eggs laid in the fall on the ground or in weeds and hollow stubble are apparently to a large extent infertile or injured by the weather so that they fail to hatch," and Parks (1914) has pointed out that eggs deposited in the autumn of 1911 in Idaho were killed by the low winter temperatures, and concludes that as far as

TABLE 2

INCUBATION OF THE EGGS OF THE ALFALFA WEEVIL

Investigator	Number of eggs per female	Incubation period, in days	Number of eggs per puncture		
			Range	Usual	Maximum
Titus (1910*a*)	200 to 300	In one lot of 1,139 eggs the incubation period varied from 7 to 16 days, averaging slightly over 10 days	1 to 28	Of 2,373 eggs the average per puncture was 6.29, and 16.61 eggs to a stalk	
Titus (1910*b*)		7 to 16 days, averaging about 10 days			
Webster (1912)		7 to 10 days About 10 days About 13 days	2 to over 30	10 about the average	Over 30
Titus (1913)	1 female may lay over 1,500 eggs; average 600 to 800		1 to 45		45
Parks (1913)	700 to 800; average number deposited by 16 females 726	8 to 15		6 to 14	
Parks (1914)	Largest number deposited 1,184, average 726; with 11 females allowed to deposit eggs in a warm laboratory during winter and spring, the average number of eggs deposited was 913; one female laid 1,918		2 to 30	6 to 18	
Hagan (1918)	600 to 800				40
List and Wakeland (1919)		Under laboratory conditions the average incubation period for the entire season was 14.69 days	1 to 30 or more		
Reeves, Chamberlin, and Pack (1920)		Eggs develop slowly at first and faster as the temperature rises, until in May and June they hatch within 2 weeks after they are laid			
Wakeland (1924)		Average length of the egg stage is about 14 days			
Snow (1925)		10 days to 2 weeks	1 to 30 or more		
Reeves (1927*b*)			4 to 16	About 10	
Sweetman (1929)		Average incubation period 2-inch level was 18.6; average incubation period 2½-foot level was 19.8	3 to 12; in solid stems 3 to 6	6 to 9	45

known, either all the eggs deposited in the autumn perish before hatching or the larvae are killed by the winter. It should be noted that the investigations of Titus and Parks were carried on prior to those of Reeves and Snow, and that the conflicting reports might easily be accounted for by differences in climatic conditions under which the investigations may have been conducted.

LARVAE

The larvae (fig. 8) of the alfalfa weevil do by far the most damage to crops. On hatching, the young larva is about $\frac{1}{32}$ inch long, light yellowish green or almost tan in color except for the black head. After the first molt the color changes to a light green. The mature larva is about $\frac{1}{4}$ inch long, with a rather wide dorsal white stripe running down its back. This white or pale stripe is noticeable in the very young larvae and becomes more pronounced as the larva matures. Also on either side there is a very faint white line. The body is marked with many wrinkles which extend around the back and sides.

It is recorded by Webster (1912) that the newly hatched larvae are remarkably vigorous and that very young ones exhibit great energy as travelers. Their mode of progression is to reach forward and then, with a slight hump, to bring up the rear part of the body. The head is at once thrust forward again. About one move is made per second, and three propulsions will carry the body forward 1 mm. When in doubt as to the direction to be taken, the larva elevates the head and swings it from side to side until some decision is reached, when the journey is resumed. The larvae are positively phototropic.

Titus (1910*a*) states that the larva in emerging from the egg does not cut an opening in making its exit from the shell, but, by muscular contractions, rolling and twisting inside the shell, obtains sufficient pressure to burst through the thin membrane.

Soon after hatching the larvae start feeding in the interior of the stalk, and sometimes remain there 3 or 4 days, before working their way up the outside of the stem to conceal themselves in the leaf buds, usually at the top of the plant. Here they generally feed through the remainder of the first stage, and sometimes during the second larval period. That the early feeding of the larvae is confined to the leaf buds or terminal growth is an observation generally agreed on by most investigators (Webster, 1912; Reeves, Miles, *et al.*, 1916; Hagan, 1918; List and Wakeland, 1919; and Sweetman, 1932). While feeding in this position the larvae are most often concealed and not easily seen. Webster (1912) points out that the selection of the terminal growth may be in part due

to the shelter offered as well as to the more tender and succulent nature of the growth, and Sweetman (1929) suggests also that the larvae seclude themselves in the growing tips and axils of plants when the alfalfa is disturbed by wind and rain.



Fig. 8.—Mature larvae of the alfalfa weevil, left, and the clover leaf weevil, right. The latter are much larger and have pink lines bordering the white dorsal stripe. Immature forms of the clover leaf weevil also have the posterior part of the body pinkish. (Photo by Matthews.)



Fig. 9.—Alfalfa plants showing the injury done by the larvae of the alfalfa weevil where an average population occurs in slightly neglected fields. Such injury is seldom noted by the grower unless his attention has been called to it. (Photo by Matthews.)

Parks (1913) records that many of the older larvae go into the crown of the plant during the day and come out to feed at night. From 6:00 P.M. to 1:00 A.M. both the larvae and beetles are found feeding in greatest

numbers, although many are found feeding all through the day. As the larvae become older they start feeding on other parts of the plants.

Reeves, Miles, *et al.* (1916) state that in the absence of control measures the larvae appear in large numbers about the end of May or earlier if the spring has been favorable, and eat the leaves, especially on the young shoots, so rapidly that the plants are unable to outgrow the injury. In general the period over which the larvae may do serious damage is from May to early in July, depending of course on location and weather conditions. The feeding increases steadily until after the height of the hatching season, but the plants are able to outgrow the injury until just before cutting time—when the larvae may become so numerous as to destroy the growing tips completely and thus stop the growth of the plants. This condition is usually reached one or two weeks before the crop is ready to be cut, and if no control measures are resorted to, serious injury results. After this period the appearance of the field changes rapidly; the leaves are consumed until nothing is left but woody fibers and the tops of the plants are as white as if they had been frost-bitten. The injury spreads downward, and before the normal cutting time, if the fields are allowed to stand, the whole plant is bare of leaves and the green covering has been stripped from the stems.

Titus (1909*b*) notes that where young larvae are forced to feed on the older leaves they only skeletonize the foliage. He further adds that this often gives the plants the appearance of having been frosted except that the color is whiter than after frost injury (fig. 10).

After the larvae have grown to be about two-thirds mature they are often easily seen on the plants, where they may be observed curled around a portion of a leaf, stem, or bud.

Wakeland's (1925) observations during four seasons showed that from the time when the number of young larvae in a field exceeds about 1,000 for each 100 strokes of the sweeping insect net until the time when they decrease to less than that number, the amount of feeding is great enough to cause serious damage.

If, at the time the first crop is harvested, there are numerous larvae in the fields, the second crop may be greatly delayed. Titus (1910*a*) calls attention to the fact that in Utah the larvae are nearly full-grown at the usual time of cutting the first crop, and that many of them crawl back to the stubble and prevent the second crop from starting for several weeks. Reeves, Miles, *et al.* (1916) also note that the larvae feeding upon the first crop gather upon the buds of the stubble, and although many have been killed by the exposure to the heat of the earth after cutting, there are still enough to prevent the growing of the second crop for a

time nearly equal to its usual period of growth. Snow (1925) adds that in Nevada where the first crop is cut early, while few of the larvae are full-grown, the second crop may be delayed 3 or 4 weeks. All investigators agree that the second crop is usually delayed until the majority of the larvae have reached maturity and pupated.



Fig. 10.- -Alfalfa plants rather seriously damaged by the larvae of the alfalfa weevil. Such injury is caused by large populations of weevils in neglected fields and may result in considerable losses. Under these conditions the injured tops become dry and whitish and artificial control may be justifiable. (Photo by Matthews.)

Wakeland (1924) also points out that an infestation which would be considered of little importance in a hay field is often sufficient to render seed production unprofitable, for since the larvae feed in the newly developing tips almost entirely, they destroy blossom buds and thus prevent seed development.

In an infested area the enormous numbers of larvae and eggs that occur to the acre is indicated by Reeves (1917) : The total number of larvae and eggs present in a measured area of a certain typical field in 1913 in Utah was equivalent to 8,240,000 per acre on May 5; to 15,650,000 on May 14; to 22,920,000 on May 21; and to 10,410,000 on May 31; and on June 5 the number shrank to 310,000 per acre, because the maturing of the larvae outran the deposition of eggs.

Table 3 summarizes a portion of the data on larval development and

gives the length of the larval period, number of molts, length of time between the individual molts, and length of pupal period.

According to Titus (1910*b*) the molting process of the larvae is about the same in all stages. He states:

> This casting-off of the skin is a rather slow process. The first evidence is the slight shortening of the larva, soon followed by the splitting of the head plate, beginning at the center of the inverted "y," the parts rolling back and then spreading a short distance down the back, rarely more than 2 segments, the larva working its way out through this opening. The cast skin soon dries and shrivels up, so that it is almost impossible to find it.



Fig. 11.—*A*, Cocoons of the clover leaf weevil; *B*, cocoons of the alfalfa weevil; *C*, cocoons of the alfalfa weevil parasite, *Bathyplectes curculionis* (Thoms.). The latter occur within the cocoons of both the weevils. Note the oblong shape of the larger cocoons of the clover leaf weevil and the more globular and smaller cocoons of the alfalfa weevil. These weevil cocoons often occur together usually about the bases of the alfalfa plants. (Photo by Matthews.)

PUPAE

Upon reaching maturity the larvae either crawl or drop to the ground, where they spin a delicate net-like cocoon (fig. 11) of white silken threads. The cocoon is roughly globular and is often partly enveloped by one or more leaves. It is lightly attached to the rubbish on the ground or to the stubble at the base of the plants. Titus (1910*a*) notes that it takes the larvae 10 to 20 hours to spin the cocoons; and from 36 to 72 hours after this they transform into the pupae. The newly formed pupa

is pale yellowish green changing to light brown as it approaches maturity. After transformation the adult weevil remains within the cocoon a few days before making its exit. It then cuts its way out of the cocoon, crawls up the stem, and begins to feed.

TABLE 3

LARVAL DEVELOPMENT OF THE ALFALFA WEEVIL

Authority	Length of larval period	Number of instars	Length of individual instars	Length of pupal stage
Titus (1909*b*)	32 to 40 days	At least 4	Each lasts from 8 to 10 days	10 to 14 days
Titus (1910*a*)			5 to 8, 12 to 20, 12 to 30	6 to 14
Titus (1910*b*)				Averages about 8 days
Webster (1912)			5 to 8, 12 to 20, 12 to 30	
Titus (1913)				10 to 14 days
Parks (1913)				About 36 hours after spinning cocoon larva changes to pupa and the adult emerges about 10 days later (during July)
Reeves, Miles, *et al.* (1916)		3 to 4 depending on the season of the year in which the larval life is spent		
Hagan (1918)				Pupa requires about 10 days to become an adult insect
List, Wakeland (1919)	21.86 average for the season	3 times with a very small percentage undergoing a fourth		Average length of pupal stage 15.82
Wakeland (1924)	About 3 weeks average			
Snow (1925)	5 to 6 weeks			7 to 10 days
Sweetman (1932)	23 to 28 days			10 to 11 days

While it is the general thing for the larvae to pupate close to the ground, Titus (1910*a*) remarks that when there is dead alfalfa such as that injured by frost, cocoons may be found 6 inches above the surface of the soil.

PARTIAL SECOND GENERATION

After the heavy egg-laying period in late spring a few eggs are deposited during the summer and into the fall. This immediately brings up the question whether any of these are laid by the new generation

of beetles. Titus (1909*b*) reports that larvae not half grown were collected on September 14. These he believed were probably belated larvae that had failed to develop as rapidly as the others, since there was no evidence of more than one brood of the weevil. Webster (1912), using color as a means of differentiating the adults, thought that the new generation of beetles probably laid eggs before winter because females depositing eggs in the fall from which larvae afterwards hatched, were in a perfect condition, unrubbed, and apparently fresh. Parks (1913, 1914) noted that in the autumn of 1912 beetles which emerged from their cocoons June 10 to 13 deposited eggs in outdoor cages the latter half of October, which to all appearances is the beginning of another generation later interrupted by the approach of winter but again continued in the spring. However, he also noted that eggs deposited in the autumn of 1911 were killed by the winter temperatures and that, as far as known, all eggs deposited in the autumn in the Great Basin perish before hatching or else the larvae are killed by the winter, according to the weather conditions. Reeves, Miles, *et al.* (1916) report that about half of the females of the new generation are ready to deposit eggs by the middle of October and that egg-laying then is chiefly in dry stems and continues for about a month. Snow (1925) has shown that the growth of a generation of female alfalfa weevils throughout the two seasons of their existence indicates that those emerging in the spring and summer remain immature for about four months at least, after emergence, or until late September and October of their first season; about half of them, with the exception of weevils on ditch banks, are capable of oviposition by the time winter sets in; weevils from ditch banks and fence rows were found without eggs during winter and early spring. On the other hand, the small number of females of the previous season which survive until August and September of their second summer is enough to account for the few eggs which are found at that time. These eggs, therefore, and any larvae which come from them, are retarded members of the old generation and not a partial new brood as suspected by some writers. In general it may be said that the larvae found during the summer are from eggs laid by females of the old generation, but it is possible that some of the young found late in the fall may be produced by the new generation of adults.

OBSERVATIONS IN MIDDLE CALIFORNIA

In middle California the alfalfa weevil lays eggs throughout the summer and to a smaller extent during the entire winter. It has not been determined how egg-laying is distributed during the different seasons.

Beetles were collected from time to time during the summer and as late into the fall as adults could easily be found in the field. In all cases eggs were obtained when the adults were caged with alfalfa. During August the egg-laying may have been at a minimum, but since no egg records were taken then it is impossible to make a definite statement concerning this particular point. The weevils were collected at random, with no attempt to separate the new and the old generations, and therefore no data



Fig. 12.—Field breeding cage used for field studies of the alfalfa weevil in middle California. It is constructed of redwood and fine wire screen and measures 3 x 3 x 1½ feet.

were obtained as to when the new generation might have begun egg deposition. So far little has been learned about the egg-laying habits of the pest during the winter. From field cages eggs were observed on January 6 and 13, 1933. All eggs were deposited in old alfalfa stems that were seriously injured by the frost. The bright color of most of the eggs indicated that they were only recently laid.

It is very possible that the activity of the insect is never completely at a standstill. All through the winter some larvae have been collected. They have never been taken in large numbers; usually a few could be collected at Pleasanton and Niles at any time, but at Tracy, in the San Joaquin Valley, no larvae or adults were taken during the winter of 1932–33. In winter the clover-leaf weevil larvae generally occur throughout the alfalfa fields, and it is at first difficult to distinguish the young larvae of this insect from those of the alfalfa weevil, but a little experience soon enables the collector to distinguish the two at sight.

Whether it is possible for the alfalfa weevil to pass through the winter in the pupal state still remains to be accurately determined, although some evidence has been obtained which indicates it does. Between October 25 and November 4, 1932, several hundred larvae were collected and placed in a field cage at Pleasanton. Some of these pupated and emerged before the cold weather set in. During December no observations were made, but on January 6 and 13, 1933, examination showed a considerable number of pupae. Some of them were dead, but many cocoons contained live pupae. All indications are that larvae maturing very late in the fall may pass through the winter in the pupal state.

CLIMATIC EFFECTS

GENERAL CONSIDERATIONS

Weather conditions greatly influence the activity of the alfalfa weevil. Data obtained from various investigators seem to show that climatic conditions largely determine the destructiveness of the pest. The weevil occurs over a wide climatic range, throughout a portion of which it will perhaps never become a serious pest. Even in the more favored regions it may not at times cause enough damage to warrant control measures. It is possible that the climatic conditions in southern Europe are such as to minimize the damage caused by this pest, although it is difficult to separate this influence from that due to cultural and biological control. A comparison of temperature and rainfall data in regions where the weevil occurs (table 4) shows a close correlation between the climate of a portion of California and that of a part of the Mediterranean region. On the other hand, the type of climate found in the Great Basin differs greatly from that of southern Europe.

In order to give some idea as to the likeness or difference of climates in the New and Old Worlds, table 4 has been prepared to show some of the more important climatological data for certain points. From this table it may be seen that the climate of Tashkent, Turkestan, is very similar to that of Salt Lake City and Boise, and that with all other factors equal, it might be expected that the damage by the weevil would be about the same in these places. Unfortunately very little information is to be had in regard to the damage done by the alfalfa weevil in Tashkent, although the literature contains several references to its being injurious. In the area around Salt Lake City the weevil causes very serious damage. Judging from the data shown in the table, probably the most important differences in the climate of these three places are somewhat higher mean annual temperatures and a somewhat higher mean temperature for the

TABLE 4

CLIMATIC CONDITIONS IN REGIONS INFESTED BY THE ALFALFA WEEVIL

Location	Elevation	Temperature					Rainfall				
		Mean annual temperature	Mean warmest month	Mean coldest month	Mean of maxima observed each year	Mean of absolute minima observed each year	Total rain	Mean maximum		Mean minimum	
								Month	Amount	Month	Amount
		°F	°F	°F	°F	°F	in.		in.		in.
Tashkent, Turkestan	1,574	56.3	81.5	30.2	104	− 4.0	14.56	Mar.	2.75	Aug.	0.00
Montpellier, France	131	56.12	72.86	41.0	96.8	19.4	30.31	Oct.	4.33	July	0.78
Toulouse, France	656	54.14	69.98	40.1	96.8	17.6	22.83	May	3.14	July	1.18
Florence, Italy	230	57.74	76.1	40.82	98.6	21.2	35.00	Nov.	4.33	July	1.57
Foggia, Italy	295	60.26	78.8	43.52	.....	.....	18.50	Nov.	2.36	July	0.78
Milan, Italy	492	54.5	74.84	32.36	93.2	14	39.76	Oct.	4.72	July	2.75
Naples, Italy	492	60.44	75.56	46.76	93.2	30.2	32.67	Nov.	4.72	July	0.39
United States											
Boise, Idaho	2,739	50.9	73.4	29.66	100.4	− 2.2	13.73	Jan.	1.98	July	0.26
Salt Lake City, Utah	4,408	51.8	76.26	28.94	98.6	− 2.2	16.23	Apr.	2.01	July	0.52
Cheyenne, Wyoming	6,088	44.96	67.46	25.52	93.2	−18.4	13.99	June	2.39	Jan.	0.38
Laramie, Wyoming*	7,188	40.8	62.9	22.6	.....	.....	11.06	May	1.47	Jan.	0.41
Fresno, California	293	63.14	81.86	45.86	109.4	24.8	9.28	Jan.	1.83	July and Aug.	0.01
Red Bluff, California	307	62.42	82.04	45.32	109.4	26.6	24.86	Jan.	4.86	July	0.03
Sacramento, California	71	59.54	72.32	45.66	104.0	28.4	18.56	Jan.	3.82	Aug.	0.01
Stockton, California*	23	59.6	73.3	45.8	.....	.....	14.44	Jan.	3.06	July	trace
Livermore, California*	485	59.7	70.3	48.6	.....	.....	15.26	Jan.	3.20	July	0.01
San Jose, California*	95	57.2	66.4	47.8	.....	.....	15.13	Jan.	3.05	July	trace
Tracy, California*	64	.....	.....	.....	.....	.....	10.26	Jan.	1.96	July and Aug.	0.01
Niles, California*	70	.....	.....	.....	.....	.....	18.78	Jan.	3.69	July	trace
Los Angeles, California	338	60.26	68.54	53.06	100.4	33.8	14.95	Jan.	3.05	July	0.01
San Francisco, California	206	54.86	59.36	49.46	89.6	33.8	22.52	Jan.	4.99	July and Aug.	0.02

* Temperature data from Koppen, cited below for foreign cities.

Sources of data:

Foreign cities: Koppen, W. Grundriss der Klimakunde. 388 p. Walter De Gruyter Co., Berlin and Leipzig. 1931.

Cities in United States: all data on elevation and rainfall, and data on temperature except for cities starred (for which see footnote starred), from: United States

warmest month at Tashkent than at the American stations. Higher maximum temperatures may be expected in Tashkent than in either Salt Lake City or Boise. It is possible that these higher temperatures may be an important factor in the control of the weevil in Tashkent.

If Salt Lake City and Boise are compared with lowland stations of southern Europe, it may be seen that these American stations have a lower mean annual temperature, and that the mean for the coldest month is much lower. It seems that these low winter temperatures may be an important factor in determining whether or not the weevil is a serious pest. Such low temperatures keep the overwintering beetles inactive, and when warm weather finally sets in there is a heavy and sudden deposition of eggs, which results in the hatching and feeding of a very great number of larvae at one time.

When the temperatures of lowland stations of the Mediterranean area are contrasted with stations located near the coast of California, considerable similarity is noted. The mean annual temperatures and other climatic factors in the two regions are so much alike that it seems certain that if the climate of southern Europe is important in reducing or controlling the weevil, the same factors must also be operative in this state. If the data for inland stations of California are contrasted with those of the lowlands of southern Europe it is seen that the summer temperatures are likely to be much higher in California. At Fresno, the mean for the warmest month is higher than that of any station listed for southern Europe, and the highest summer temperatures greatly exceed any other in the table, except that for Red Bluff. It is likely then that the hot summers of the California interior valleys may be severe enough to check the alfalfa weevil to such an extent that it will not become a pest in any sense of the word, even though it may in time spread throughout these areas.

When rainfall is compared it is noted that several southern European points receive a greater precipitation than that listed for some California stations, but in spite of this much similarity is to be found in the precipitation of the two areas. However, it has been reported that moisture favors fungus diseases of this pest, and an examination of the table shows that southern Europe receives considerably more summer rainfall than the low-lying regions of California. This may be a factor in controlling the pest in its native home. The most important difference to be noted is in the hotter, dryer, interior valleys of California. Their greater dryness, coupled with very high temperatures, may also affect the weevil adversely.

Reeves (1927*b*) states that within the limits of its spread in 1927 it

occurred wherever alfalfa was grown in the United States, regardless of altitude and local climate. As a serious pest, however, it seemed to be confined to the lower valleys, presumably because of their warmer climate. It was noticeable also that even there it reached great destructiveness only in the warmer seasons. Cook (1925), after a careful review of the literature, and a study of the conditions under which the insect occurs in its original home, states:

> In the case of the alfalfa weevil the limiting periods are two in number—the temperature limit, which applies largely to the hibernating adults, and the humidity limit, which applies to the larva and its fungus enemies.
>
> * * * * * *
>
> Broadly speaking, the alfalfa weevil is limited on the north, inside the Pacific and sub-Pacific rainfall regions, by low summer temperatures; on the east, at the edge of the sub-Pacific type, by heavy summer rainfall; and on the northeast, in the plains of Montana and Wyoming, by the summer rainfall and by low winter temperatures, plus a very light snowfall. No data have been found upon which to base a limit on the south, but it is possible that the high temperatures of southern California and Arizona may prove fatal to larvae.

He further divided the region over which the pest might occur into three zones: (1) The areas of normal occurrence where climatic conditions are most favorable to the insect development, (2) regions whose normal climate departs slightly from the optimum, and may be regarded as subject to periodic infestations when the climatic variations are towards the optimum, and (3) areas whose normal climate varies widely from the optimum, and in which favorable conditions rarely occur. In this latter area he states that the weevil will probably not be able to maintain itself, but may be repeatedly introduced and become of minor importance after a series of favorable seasons. According to Cook's investigations the alfalfa weevil is fast reaching the outer zone over which it might occur. That the climatic conditions of eastern Wyoming may be reaching the limits within which spread of the weevil can take place is further indicated by Sweetman (1929):

> The alfalfa weevil has lost ground on the eastern front of the infested territory of Wyoming in the last two years. It was found at Torrington in 1926 and 1927 and at Manville in 1927, but these infestations have apparently disappeared, as scouting work in 1928 and 1929 failed to reveal its presence. While it is impossible at the present stage of these investigations to account for the disappearance, a climographic study of the two places shows that the winter of 1927 was extremely dry and December temperatures were below the average. The weevil has failed to overwinter under outdoor conditions at Laramie where the winters are normally dry.

Other findings of Sweetman (1929) showed that the removal of a crop of hay produced temperature changes close to the ground which might be extremely disastrous to immature stages of the pest; he states: "The

soil surface in alfalfa fields, when exposed to the sun, often reached temperatures between 50° and 60° C [122° and 140° F], unless the soil was quite moist." He found that the temperatures of the alfalfa stems, leaf surface, and growing tips were very close to those of the air surrounding them between 7° and 42° C (44.6° and 107.6° F).

Reeves and Hamlin (1931*a*) also point out the importance of climate. Their investigations show that the temperature conditions at the time the first crop is removed may result in a very great mortality of the immature stages of the pest. Further, they found that it is largely the few eggs which are laid on the second crop that give rise to the adults which cause the infestation the following spring. Owing to the warmer weather during the growth of the second crop, larval development is rapid, and the larvae pupate and emerge before cultural kill comes into play at the second cutting, which, coupled with a very small amount of parasitism, allows these individuals to survive. Reeves and Hamlin sum up the matter of parasitism as follows:

> In the unsuspected significance of this population lies the solution to that perplexing question, how we could experience nearly perfect parasitism one year and still have sufficient new-generation adults produced to cause weevil injury the following year. The explanation is now simple: namely, that the apparently unimportant second-crop larval population is so little affected by either biological or cultural kill, that it serves to maintain the adult population at an economically dangerous level.

It should be pointed out that if the first crop is not cut until after some of the adults have emerged, the importance of the second-crop adults is not so marked.

UPON THE ADULTS

That the adult weevils react readily to temperature is seen from the work of a number of investigators. Titus (1909*b*, 1910*a*) and others report that they are very susceptible to warmth, and that even the passing of the sun behind a cloud may be the cause of their leaving the upper foliage and seeking protection below. Overwintering adults become active with the first warm days of spring, and the degree of their activity throughout the season is largely dependent upon temperature. Titus (1910*a*) further noted that the weevils are very susceptible to climatic conditions during the period when they are going into hibernation, and a cold rain following a very hot day will so chill those that have not been able to get into proper shelter that many will not survive the night. During the warmer part of early spring days weevils have been noticed mating, and egg-laying commences soon after they come from hibernation. Reeves, Miles, *et al.* (1916) say that there is no definite hibernation in the case of the weevil. The adults are active when it is warm and quiet

when it is cold. A female taken from a frozen field will feed immediately and oviposit in a few hours after being brought into a warm room. However, it is further stated that many of the weevils die in the fields during zero weather, although milder winter temperatures seem to have little injurious effect upon them.

Sweetman (1929) found that the adult weevils became active in the morning when the temperature reached 10° to 12° C (50° to 53° F). He also observed that activities on the plants and in the shade on the ground increased as the air became warmer, and that there was some evidence of the avoidance of direct sunlight on the soil surface when the temperature reached about 35° C (95° F). During the months of May, June, and July, in 1927, 1928, and 1929, he observed no evidence of flight to escape high temperatures. Further observations showed that cloudy weather apparently had no effect on the reactions of the adults; their activities seemed to be regulated by the temperature rather than the amount of sunshine. Sweetman (1932), observing the activities of the beetles during warm nights in the middle of June, reports that movement, feeding, and mating continued as during daylight hours when the temperature was high enough.

Sweetman and Wedemeyer (1933) report that under controlled conditions relative humidities below 40 per cent, at least with temperatures of 27° C (80.6° F) or higher were very destructive to the adults, and Reeves (1917) noted that a temperature of 120° F is fatal to the insect, while in Idaho (Idaho Agricultural Experiment Station, 1926) the unusually low temperatures of December, 1924, are stated to have resulted in 95 per cent mortality of the pest.

UPON THE LARVAE

The effect of temperature upon the larvae is important. According to Sweetman (1929):

> The larvae may seek shade and cool places when the temperature reaches about 30° C [86° F], but they are often exposed to direct sunlight when the temperature is higher. They seclude themselves in buds, axils, and lower on the plants at times to avoid heavy rains, strong winds, and extreme heat. . . . There is also some evidence of seclusion in rubbish and crevices in the soil during the midday heat following the harvesting of the crop.

Sweetman (1932) also states that the length of the developmental periods was closely associated with temperature and that "The minimum effective temperature for development during the feeding period is about 10° C [50.0° F], but during the pupation period is about 13° C

[55.4° F]." He was also able to study the effect of freezing temperatures upon the larvae and reports:

> An excellent opportunity developed on June 20 to determine the effect of freezing temperatures on the larvae. The minimum temperature at the top of the plants was about —2° C [28.4° F], and remained below freezing for about 2 hours, killing the upper inch or two of many of the plants. A large number of frozen portions of the stems were removed and examined before the larvae became active in the morning. Many larvae were found and all of them appeared to be normal in every way and resumed feeding when placed on fresh plants.

Observations of the larvae during the warmest nights revealed that they were secluded and inactive during darkness under the conditions observed. As daylight appeared they became active and were exposed on the outer parts of the plants if the temperature was favorable. (Sweetman, 1932.)

Sweetman and Wedemeyer (1933), working under controlled environments, found that "the favorable region for larval development was between temperatures of about 20° to 30° C [68° to 86° F] with relative humidities ranging from 95 per cent to at least as low as 30 per cent. Temperatures above about 34° [93.2° F] destroyed the larvae."

UPON THE PUPAE

Pupae that are left unprotected in the field after the removal of the hay crop may be considerably affected by temperature. The hot, dry weather of the western summers appears to kill many of the pupae left unprotected on the ground after the first crop is removed (Parks, 1913). Sweetman (1929) collected cocoons, which remained unprotected on the ground for varying periods of time, and found the emergence of the adults to be 17 per cent greater from cocoons exposed less than one day than from those left in the field for a longer period.

TEMPERATURE IN RELATION TO EGG-LAYING

All investigators appear to believe that egg-laying is greatly influenced by weather conditions, particularly temperature. Parks (1913) states that a prolonged cool spring results in the extension of egg-laying over a long period of time, so that the number of larvae feeding at any one time is less, and the injury resulting not so great but that the plant will have a chance to recuperate. Experiments carried out at Salt Lake City showed that the rate of egg-laying was directly dependent upon the mean daily temperature during the time of egg deposition. He found that a cold day will check egg-laying while one or two warm days will greatly increase it. Titus (1913) noted that when warm weather con-

tinues throughout the day, and the alfalfa is from 6 to 8 inches tall, egg-laying is begun in earnest. Webster (1912) points out that in 1909 egg-laying began in the fields early in April, and eggs were found in greatest abundance during the last of May and the first of June. However, in 1910 egg-laying began early in March and was at its height by the middle of May. Hagan (1918) reports that if the weather is warm and dry, egg-laying is completed within a few days, but if the season is cold and wet it may be extended over several weeks. Sweetman (1929) found that the number of eggs laid increased during warm weather, and that the correlation between egg-laying and temperature is very marked. He reports that on one day having a mean temperature of 39.2° F during a time of heavy egg production, 13 females failed to lay any eggs while 2 others laid 15, but that on the day preceding and following this cold one over 100 eggs were laid by the 15 females. He also showed that many eggs laid in dead stems are destroyed by the high temperatures to which they are subjected.

Later Sweetman and Wedemeyer (1933) found that under controlled conditions: "The favorable region for oviposition of the adults apparently was below a temperature of 28° C [82.4° F] with relative humidities between 50 and 95 per cent. Temperatures of 30° to 37° C [86° to 98.6° F] were very injurious, especially when the relative humidity was high, while higher temperatures killed the adults in a few days."

EFFECT OF ELEVATION

In the discussion of general climatic conditions the effect of elevation has been mentioned in several places. In general it has been noted that with an increase in elevation, beyond a certain level, weevil injury becomes less, owing to cooler spring temperatures and more severe winters. According to Webster (1912) "Latitude and elevation, with the consequent modifications of temperature, will have much to do in deciding the time of emergence from winter quarters in spring." Parks (1913) states that when the larvae are numerous they may stop the growth of the plants, and adds that this occurs in June in fields having an altitude of from 4,000 to 5,000 feet, and during July in fields having an altitude of from 5,000 to 6,000 feet. He further remarks that there is no reason to expect that the cold winters which prevail in the high altitudes in much of southeastern Idaho will control the pest, since they thrive in the mountain valleys of Utah at an altitude of from 6,000 to 7,000 feet. However, during the time of his investigations there were a number of years during which climatic conditions were very favorable to the insect, and since the publication of his work it has been noted that the cold tem-

peratures of certain high altitudes may effectively control the pest. Titus (1913) reports that in the higher mountain valleys, the weevils reach the adult stage later in the summer, and enter into hibernation earlier. Cook (1925) reports: "The damage decreases with an increase in elevation. An increase in altitude in this region is equivalent to a shortening of the growing season plus an increase in precipitation."

WEATHER CONDITIONS IN RELATION TO CONTROL

That weather conditions exert a marked influence on the weevil is best illustrated by the effects upon its control. If a season is favorable to the development of the pest in those areas where it has become abundant, then it may be necessary to resort to artificial methods of control to obtain a profitable crop. Reeves, Miles, *et al.* (1916) point out particularly that in years when there is an early spring, the weevils are stimulated to early activity, and this fact must be taken into account in any attempt to protect the first crop. Under such conditions larvae hatching from eggs laid early along with those laid the previous fall, sometimes attack the plants in numbers large enough to cause serious injury to the crop before the majority of the eggs have been laid.

Certain climatic conditions greatly influence the time of the season that damage becomes most apparent. It is claimed that in warm seasons the plants get an early start, which tends to postpone the critical point, at which time spraying should be done, but since this condition is more than offset by the rapid development of the weevils, the damage is also likely to come early. On the other hand in a cold backward season the growth of the plants is hindered by the weather, but not to the same degree as are egg-laying, hatching, growth, and feeding of the weevils, and thus the crop becomes nearly mature before its growth is halted by them. It is also stated that a heavy frost during the growing season has but little effect upon the weevil. It merely delays the weevil's activities for a few hours, but it may seriously stunt the alfalfa plants and puts them at the mercy of the weevil larvae, somewhat as does the cutting of the first crop. Wakeland (1920) reports a condition where a freeze occurring on June 1 greatly reduced the rate of plant growth and the injured alfalfa was therefore unable to withstand weevil attack as normal healthy plants should.

Snow (1925) states that cool and damp weather throughout the spring followed by bright weather after the time of haying appears to have controlled the weevils in Utah during certain years. Chamberlin (1924*a*) points out that in general warm and dry weather in the late winter and early spring followed by cool and damp weather at haying time, allows

the weevil not only to develop early and rapidly, but also protects it from great mortality often caused by heat at the time of cutting the first crop. Conditions which do not favor excessive damage are: (1) cool moist spring weather which aids the growth of the alfalfa and slackens the egg-laying of the beetles as well as the feeding of the greatly reduced number of larvae; (2) clear hot harvest weather, which kills many of the larvae and thus makes it unnecessary to protect the second crop. Reeves (1927*b*), commenting on the fluctuation in injury, says:

> This variation in damage is explained by the stimulating effect of warmth upon egg production. The nine years during which this weevil was invariably destructive were for the most part abnormally warm during the egg-laying season in April and May, as were also those of the later years in which the damage was serious. The climate of the Great Basin region is such that there is only a short time when the temperature is favorable to egg-laying, before the first crop matures and can be removed from danger. Under such conditions a late spring, by delaying the egg-laying, may allow the hay crop to be harvested before enough larvae can hatch to do it much harm. This happens often in the warmer valleys and nearly always in the colder regions.

HOST PLANTS

The food plants of the alfalfa weevil are mainly members of the pea family, Leguminosae, upon which the larvae and adults feed. The larvae are more restricted in their feeding habits than are the adults, and in listing the hosts it is necessary to be somewhat specific in this respect. The adult females normally oviposit in the stems of the food plants of the larvae, but they often attach their eggs to the leaves and stems or oviposit in plants on which the larvae cannot subsist. For instance, in confinement the adults have been observed to feed on and to oviposit freely in the stalks of geraniums, whereas the larvae will soon starve if restricted to that diet. In the field Titus (1913) reports that eggs have been found deposited in many grasses, grains, and weeds, but very few of the larvae hatching in such places survive, because their slow mode of progression usually prevents them from reaching suitable food plants.

Reeves (1927*b*) states that "It is believed, though not definitely proved, that the weevils' ability to feed upon wild legumes accounts for the ease with which it spreads through thinly settled regions where alfalfa fields are many miles apart."

In order to give some idea of the host selection of the insect, table 5 has been prepared to show the general range of plants on which it might feed. The table also includes such plants as potato, raspberry, cabbage, and cotton, which are attacked only by the adults; but none of these plants have been recorded as supporting the pest in this country. Of the

TABLE 5

HOST PLANTS OF THE ALFALFA WEEVIL

Host	Parts infested	Relative importance of injuries	Stage of weevil feeding	Localities where injuries were noted	Authority and reference to literature
Alfalfa, *Medicago sativa*	Leaves,stems	Often serious; may destroy crop	Larva, adult	Throughout range in Asia, Europe, North America	.....
*Astragalus creophilus**	.....	.....	Larva.....	Utah.....	Webster (1912)
Astragalus utahensis See vetch	.....	.....	.....	.....	.....
Black locust, *Robinia pseudacacia*†	.....	.....	Larva.....	Utah	Webster (1912)
Bean, *Phaseolus vulgaris*†	Leaves,stems	Slight	Adult.....	Germany.....	Lüstner (1923)
				Utah.....	Webster (1912)
					Titus (1913)
Clover					
alsike, *Trifolium hybridum*†	Leaves.....	.....	Larva, adult	Utah.....	Titus (1910*a*)
					Webster (1912)
bird, *Lotus corniculatus*	Foliage.....	.....	.....	Germany.....	Krüger (1933)
bur, *Medicago hispida*†	Leaves.....	.....	.....	Great Basin.....	Parks (1913)
Medicago hispida var. *confinis*† var. *nigra*† var. *terebellum*†	Leaves.....	.....	Larva.....	Utah.....	Webster (1912)
crimson, *Trifolium incarnatum*	Leaves.....	.....	Larva, adult	Utah.....	Titus (1910*a*)
red, *Trifolium pratense*†.....	Leaves.....	.....	Larva, adult	Great Basin.....	Parks (1913)
				Utah.....	Titus (1910)
					Webster (1912)
					Parks (1913)
white, *Trifolium repens*†	Leaves	.....	Larva, adult	Great Basin.....	Titus (1910*a*)
					Webster (1912)
white sweet, *Melilotus alba*†	Leaves.....	Slight.....	Larva, adult	Utah.....	Titus (1910*a*, 1913)
					Webster (1912)
				Great Basin.....	Parks (1913)
					Reeves (1927*b*)
yellow sweet, *Melilotus officinalis*	Leaves.....	.....	Larva, adult	Utah.....	Titus (1910*a*)
				Great Basin.....	Reeves (1927*b*)
Melilotus indica	Leaves.....	.....	Larva.....	Utah.....	Webster (1912)
Melilotus sp.	Leaves,stems	Slight to severe	Larva, adult	France	Picard (1914*a*)
Cabbage, *Brassica capitata*	Leaves.....	Slight.....	Adult.....	Germany.....	Lüstner (1923)
Cotton, *Gossypium* sp.	Small seedlings, buds, top roots	Severe.....	Adult.....	Turkestan.....	Yakhontov (1929)

* These plants were eaten by the larvae when no other food was offered, but refused in the presence of alfalfa.

† In cages the larvae fed freely on these plants, in the presence of alfalfa.

TABLE 5—(*Concluded*)

Host	Parts infested	Relative importance of injuries	Stage of weevil feeding	Localities where injuries were noted	Authority and reference to literature
Downy lupine, *Lupinus* sp.*	Leaves		Larva	Utah	Webster (1912)
Fenugreek, *Trigonella foenumgraecum*†	Leaves		Larva	Utah	Webster (1912)
*Hedysarium mackenzii**	Leaves		Larva	Utah	Webster (1912)
Lotus corniculatus	Foliage			Germany	Krüger (1933)
Medicago echinus†	Leaves		Larva	Utah	Webster (1912)
muricata†	Leaves		Larva	Utah	Webster (1912)
orbicularis†	Leaves		Larva	Utah	Webster (1912)
scutellata†	Leaves		Larva	Utah	Webster (1912)
See also alfalfa, clover, and nonesuch					
Nonesuch or black medick, *Medicago lupulina*†	Leaves		Larva, adult	Utah	Webster (1912); Titus (1913)
Pea, chick, *Lathyrus sativus**	Leaves		Larva, adult	Utah	Webster (1912); Titus (1913)
sweet, *Lathyrus odoratus*†	Leaves		Larva	Utah	Webster (1912)
Potato, *Solanum tuberosum*	Leaves		Larva	Germany	Lüstner (1923)
Raspberry, *Rubus* sp.	Leaves		Adult	Germany	Lüstner (1923)
Spider plant, *Cleome serrulata**	Leaves		Larva	Utah	Webster (1912)
Vetch, wild	Leaves		Larva, adult	France	Picard (1914*a*)
				Great Basin	Parks (1913)
hairy or winter, *Vicia villosa**	Leaves		Larva	Utah	
narrow-leaved, *Vicia* sp.†	Leaves		Larva	Utah	
obtuse-leaved, *Vicia* sp.†	Leaves		Larva	Utah	
purple, *Vicia atropurpurea**	Leaves		Larva	Utah	Webster (1912)
spring, *Vicia sativa alba**	Leaves		Larva	Utah	
Utah milk, *Astragalus utahensis*†	Leaves		Larva	Utah	
*Vicia dispema**	Leaves		Larva	Utah	

* These plants were eaten by the larvae when no other food was offered, but refused in the presence of alfalfa.

† In cages the larvae fed freely on these plants, in the presence of alfalfa.

cultivated crops, alfalfa seems to be the only plant that is severely injured. Plants belonging to the genera *Medicago* and *Melilotus* apparently are favored the most.

STUDIES OF CALIFORNIA HOST PLANTS

In order to secure further data on the host range of the insect, work was started in July, 1932, to determine what plants were preferred by the weevil. Up to the present time 35 plants have been experimented with, all of which were legumes. Some of these investigations were started so late that it is hardly to be expected that conditions were favorable for weevil development, and in the case of a number of plants the tests will be repeated. To date 7 different species of plants belonging to 3 genera have been found on which the weevil can pass through all stages of development. They are *Medicago sativa, M. hispida, Melilotus alba, M. indica, M. hubamensis, Vicia dasycarpa,* and *V. villosa.* It further appears that *Trifolium repens, T. hybridum,* and *Vicia calcarata* are suitable host plants. In the case of the first two the plants became so heavily infested with aphids that the work of the alfalfa weevil was masked. However, larvae of different sizes were observed on these plants and it is likely that under favorable conditions these would complete their development, and it is possible that they did so, although no cocoons were observed. The adult weevils fed to a greater or lesser degree on all the plants experimented with.

The following procedure was used in determining the host plants. The plants were grown from seed in 10-inch flower pots. After they reached a fair size, adult weevils were caged on them. The number of the latter varied from about 25 to 100 per cage, largely according to the denseness of vegetation.

The adults fed on all plants; some plants on which no larvae were seen were severely attacked. Among these plants were large and small lima beans, sweet peas, soybeans, and a few others. So severe was the injury by the adults that all plants falling in this category will be further experimented with. It seems possible that under proper conditions the pest will pass through its entire life history from egg to adult on at least some of these plants.

For the most part, when the weevils were placed in the cages, they laid eggs over the different parts of the plants and in a number of cases deposited the eggs on the surface of the soil. In a few instances eggs were also deposited within the stems of jack bean, and the large lima bean.

Table 6 has been prepared to show the results obtained to the present time. Further work may change this somewhat.

Under natural conditions the weevil has been found breeding on three different hosts besides alfalfa. These are: bur clover (*Medicago hispida*), yellow sweet clover (*Melilotus indica*), and white sweet clover (*Melilotus alba*). Their importance is probably in the order given. On April 21, 1933, the larvae of the alfalfa weevil were found with great ease feeding on bur clover, and to a lesser extent on yellow sweet clover from Pleasanton to Niles via Niles Canyon. On May 10 an examination showed the weevil to be rather abundantly distributed on yellow sweet clover over

TABLE 6

POSSIBLE HOST PLANTS EXPERIMENTED WITH IN CALIFORNIA

Name of plant	Favorable as a host (weevil able to pass through entire life cycle on it)	Amount of feeding by adults	Date of infestation	Number of weevils per cage
Alfalfa, *Medicago sativa*	Yes	Heavy	July 22, 1932	35
Bean:				
adzuki, *Phaseolus angularis*		Moderate	July 19, 1932	35
asparagus, *Vigna sesquipedalis*		Moderate	July 12, 1932	30
baby lima, *Phaseolus lunatus*		Heavy	July 15, 1932	30
blackeye, common, *Vigna sinensis*		Moderate	July 15, 1932	52
Brabham, *Vigna sinensis*		Moderate	July 12, 1932	60
California lima, *Phaseolus limensis*		Heavy	July 8, 1932	30
hyacinth, *Dolichos lablab*		Heavy	July 12, 1932	40
jack, *Canavila ensiformis*		Heavy	July 19, 1932	35
kidney, *Phaseolus vulgaris*		Heavy	July 8, 1932	55
rice, *Phaseolus calcaratus*		Moderate	July 22, 1932	35
small white, *Phaseolus vulgaris*		Heavy	July 8, 1932	59
soy, *Soja max*		Heavy	July 19, 1932	35
Black gram, *Phaseolus mungo*		Light	July 26, 1932	25
Clitoria ternates		Light	August 4, 1932	30
Clover:				
alsike *Trifolium hybridum*	Probable	Heavy	October 4, 1932	67
Egyptian or Berseem, *Trifolium alexandrium*		Moderate	September 29, 1932	75
red, *Trifolium pratense*		Heavy	September 29, 1932	80
toothed bur, *Medicago hispida*	Yes	Heavy	August 31, 1932	89
yellow, *Melilotus indica*	Yes	Heavy	September 29, 1932	107
white, *Trifolium repens latum*	Probable	Moderate	October 17, 1932	23
white sweet, *Melilotus alba*	Yes	Heavy		
Cyamopsis tetragonolobus		Moderate	July 26, 1932	30
Green or golden gram, *Phaseolus aureus*		Moderate	July 22, 1932	35
Lupinus sp.		Light	July 8, 1932	50
Melilotus hubamensis	Yes	Heavy	September 29, 1932	75
Mexican garavanzas, *Cicer areitinum*		Light	July 26, 1932	50
Pea:				
pigeon, *Cajanus indicus*		Light	July 22, 1932	35
sweet, *Lathyrus odoratus*		Heavy	July 15, 1932	30
Peanut, *Arachis hypogaea*		Heavy	July 19, 1932	40
Vetch:				
Vicia dasycarpa	Yes	Heavy	March 3, 1933	50
hairy, *Vicia villosa*	Yes	Heavy	April 3, 1933	50
purple, *Vicia atropurpurea*		Heavy	July 8, 1932	36
spurred, *Vicia calcarata*	Probable		April 3, 1933	50

this same area. A further search showed it to be present on white sweet clover, although on this plant it was rather difficult to find. There is apparently no way to check the weevil spread on its natural hosts, on which it has now become well established. It will probably spread most rapidly where these plants grow most vigorously and where they are protected from severe grazing. One would expect these places to exist for the most part along railroads, roads, streams, and in the low river lands.

DESTRUCTIVENESS

IN OLD WORLD

From available literature and reports it is difficult to derive any very definite ideas concerning the destructiveness of the alfalfa weevil in Europe and Asia. The methods of farming are so different from those in America that it is difficult to draw conclusions. It therefore seems advisable to quote the various Old World authors, who have, during the past ten years, reported upon this insect.

In northern Europe it seems to be of little consequence as a pest.

Sweden, 1917.—A report states that it has not been recorded in that country since 1903, when it was observed attacking alfalfa in some localities in Scania (Tullgren, 1917).

Denmark, 1917.—The larvae of the alfalfa weevil were very common on alfalfa in June and July in some localities and did serious damage (Lind, Rostrup, and Kølpin Ravn, 1917).

France.—1914: The alfalfa weevil is chiefly a pest of the second crop of alfalfa in southern France (Picard, 1914*a*).

1921: Alfalfa reported as suffering from the attacks of the alfalfa weevil (Marchal and Foex, 1921).

"In our experience," writes Chamberlin (1924*b*), "weevils were most plentiful in the Rhone Valley between Valence and St. Rambert, near Lons-le-Saunier, Chambery, Annecy, and Gap. There were several fields in or near Hyères which contained a fair number of weevils."

Spain, 1929.—The alfalfa weevil was first discovered as a pest of alfalfa in 1929; not previously noted in Spain (Spain, 1929).

Germany.—1922: Damage was done to alfalfa by the larvae of the alfalfa weevil. "According to Reh, it attacks beans, cabbage, and raspberries, and the larvae eat potato foliage" (Lüstner, 1923).

1929: The alfalfa weevil was noted as a new and important pest of alfalfa in various parts of Saxony (Molz and Müller, 1929).

1933: Reported as feeding on bird trefoil in Germany (Krüger, 1933).

Bulgaria, 1931.—The alfalfa weevil caused damage to alfalfa in many localities (Chorbadzhiev, 1931).

Russia—European.—1913: The alfalfa weevil was listed among the insects injuring the leaves and stalks of alfalfa in Kiev (Vassilier, 1913).

1916: The alfalfa weevil was very numerous in the Caucasus during that year (Uvarov, 1917).

1924: The insect occurred frequently in the alfalfa fields in the districts of Lublin and Kielce (Woroniecka, 1924).

Russia—Asiatic.—1913: The alfalfa weevil was most numerous and injurious near Tashkent in March (Smirnov, 1913).

1914: The alfalfa weevil was a pest of alfalfa in Turkestan (Plotnikov, 1914).

1917: The alfalfa weevil appeared in large numbers in an alfalfa field near the station at Tashkent and greatly injured the foliage of alfalfa (Dvornitchenko, 1917).

1928: A serious deformation of young cotton seedlings in Turkestan noted in 1928, was due solely to the alfalfa weevil, which injured the buds and the tops of the roots (Yakhontov, 1929).

From these reports it will be noted that no large general outbreaks occurred anywhere during the period from 1912 to 1932 and that in no single district was the insect reported to be a serious pest during two or more consecutive years. As a matter of fact European and Asiatic entomological literature does not at all emphasize the importance of this insect as a pest of great or even ordinary economic importance.

IN UNITED STATES

Under certain conditions the alfalfa weevil becomes destructive throughout most of its range in the United States (fig. 2). The conditions which allow for considerable damage have been treated previously in this paper. Almost every article that deals with the pest in this country points out the tremendous damage it is capable of causing. Thus Reeves, Miles, *et al.* (1916) speaking of Utah say: "The damage to the first cutting ranges from slight depreciation of the quality of the hay to almost total loss, varying according to the rate of growth and the time of harvest; it may be estimated at 50 per cent. The damage to the second cutting, if no effort is made to prevent it, amounts to total loss. The menace to this state, therefore, involves one-half of the yield, worth $3,000,000." In 1927 Reeves (1927*a*) states that for "the first nine years of its history in the United States the weevil not only spread rapidly, but it is said to have nearly destroyed the first cutting of alfalfa year after year without interruption."

Fortunately conditions are not always so favorable for the pest, and

during later years it has only been really destructive in those seasons when suitable climatic conditions have existed in particular localities.

Hagan (1918) states that the injury to the alfalfa crop still aggregates an enormous sum annually, but he also points out that many farmers in the infested area are cutting more hay than before the appearance of the pest, owing to the adoption of better cultural methods.

In middle California, where the insect has been present a number of years, serious damage has been noted in poorly kept fields in several localities, where in the spring of 1933, as many as 3,000 to 6,000 larvae were taken per 100 sweeps of the insect net. It may be that large populations build up until the first cutting, after which they diminish rapidly in numbers. Last year (1932) the first counts were not made until the second cutting was well under way on June 1. In spite of the large numbers of weevils on the plants their presence has usually not been noticed by the alfalfa growers in any place unless their attention has been called to it.

DISSEMINATION OR SPREAD

GENERAL CONSIDERATIONS

As to the manner by which the alfalfa weevil was introduced into Utah, Webster (1912) states in regard to the locality where the weevil was first observed in that state, that "Although not far distant from nurseries, it is not in close proximity to any railway; it is on the other hand among the habitations of the more humble class of people, such as have come from foreign countries. The correct inference, therefore, would seem to be that it was introduced with nursery stock or in household effects of emigrants." He also reports that the habit of the beetle to hide away in any crevice or aperture that will accommodate it doubtless has considerable to do with its diffusion and that it is absolutely impossible to lay down any law that appears to regulate the diffusion of the insect. As a matter of fact the beetles are repeatedly being found where least expected, and they have not been found where, judging from their habits, they would be most confidently expected.

Parks (1913) notes that thus far no mountain ranges appear to obstruct the progress of the beetles and that the larvae and adults have been found feeding in mountain canyons on isolated alfalfa plants far removed from cultivated fields. Titus (1913) substantiates Parks and adds that alfalfa has escaped from cultivation in many places over the state (Utah) and whether it is found on the mountain sides, in the canyons, or growing wild in sagebrush areas, weevils will nearly always be found feeding on the buds and leaves. He also reports finding the weevil

as high as 9,500 feet. Reeves (1917) notes that the spread of the weevil has been slow and uniform regardless of the character of the country, whether cultivated or wild, and the insect has dispersed in an ever widening circle at the rate of about 10 to 20 miles each year, and apparently without much regard as to what are commonly supposed to be natural aids or hindrances to the dispersion of insects. No natural barriers against the weevil exist; he further notes that it has profited but little from artificial aids to its progress; and in the absence of any known method of preventing the continued spread of the weevil it may be assumed that it will reach all the alfalfa-growing regions of the continent.

Another possible way in which the weevil may be carried for rather long distances, is in the blankets of tramps, which have been spread in infested alfalfa fields or in infested hay. As far as is known no infestations have been traced to this source, although it is the belief of some entomologists that the new infestations in middle California may be accounted for in this manner.

It may be inferred from the discussion which follows that all of the ways by which the weevil has been carried to new and distant places are not fully known. Fortunately there have been but few long jumps, and most of these cannot be considered very serious. Reeves (1927*b*) reports three great skips to have been made in the progress of the weevil, aside from its original introduction: One colony was established at Paonia, Colorado, one at Reno, Nevada, and one in New Plymouth, Idaho. He further states "In effect these leaps have increased its total dispersion but slightly, as the general spread of the insect has now nearly reached the zone in which these localities lie with respect to the original center of infestation." Newton (1926*a*) calls attention to the fact that before the occurrence of the weevil in Colorado, the pest had made no outstanding jumps to new districts in America and adds that in recent years there have been isolated infestations in the states of Idaho, Oregon, Nevada, California, and Wyoming. Cole (1932) later reported a new infestation of the weevil in Jackson County, Oregon, which was another long jump.

The most recent jump of the weevil to come to light is that in middle California, including five counties in the neighborhood of the San Francisco Bay region. This infested area was not discovered until May 13, 1932, but from all appearances it is of rather old standing, for the area covered is rather extensive, and is not a continuous district. The region is divided by at least two ranges of more or less barren hills, which are of considerable size.

Table 7 shows the long jumps made by the weevil and the place and time the infestations were first observed.

DISSEMINATION BY FLIGHT AND CRAWLING

Once the alfalfa weevil becomes established in an area, its most important means of dissemination appears to be by flight and crawling. These natural means undoubtedly carry the weevil slowly outward from the infested area. Titus (1909*b*, 1910*a*) reports, "the principal means of distribution of the weevil at the present time is that of migration by the adults in the summer and fall." He also states that they are strong walkers, untiring and steady, and remarks that he has found them scat-

TABLE 7

LONG JUMPS IN DISTRIBUTION MADE BY THE ALFALFA WEEVIL IN THE UNITED STATES

Locality	When first observed	Reference
Delta County, Colorado	1917	
Washoe County, Nevada	1920	
Payette County, Idaho	1918	
Oregon, eastern	1928 shows several isolated areas not connected to main body	Shown in map, U.S. Dept. Agr., Bur. Ent., 1928, p. 352
Jackson County, Oregon	1929	Cole (1932)
Five counties in middle California	1932	

tered all across a 40-acre piece of uncultivated land, moving away from the alfalfa field on one side, many of them eventually reaching an uninfested field on the opposite side of the "forty;" and that probably the most prevalent and, at the same time most noticeable, means of spread are the spring and summer flights. He further states that each spring the adults may be found flying for a period of about 6 weeks, and that the summer flight is for a shorter period. He further points out that at all times of the year when they are active, they may be seen crawling through the fields, and during the migrating seasons, both spring and summer, may be found in almost all parts of the infested region, generally moving from one place to the other during the warm sunny portion of the day. However, he continues that the distribution of the pest appears to be almost entirely by flight.

A. J. Cook (1911) reports that the weevils are active in early summer and may fly long distances, aided by the wind. Webster (1912) also states that there is a spring and summer flight and remarks that the spring flight of the individual female is perceptibly shorter than the second migration owing to their being more or less heavily laden with

eggs. During the summer flight the beetles fly high in the air and over long distances. Parks (1913) adds that the weevils fly during two seasons of the year. The first occurs in early spring when the pest is leaving winter quarters, and the second in July and August when the new generation of beetles has appeared, and when many fly into the air and leave the infested fields to be carried to new ones beyond. Beetles were observed on April 12, 1912, falling indiscriminately in alfalfa and grain fields, along roadsides and right-of-ways, and alighting within a few feet of open ore cars in the railway yards at Salt Lake City.

Reeves, Miles, *et al.* (1916) report that the flight of the weevil is less general and extensive than it was once supposed to be; that all records which are definite and authentic show that only small numbers of the weevils are in flight at any time; that there is no evidence that the weevils ever fly for the purpose of seeking fields of alfalfa, either new or previously infested, or to find hibernation quarters. They believe the most plausible theory is that their flight is caused by rises in temperature, as are many activities of lower animals, and as far as can be determined, this flight is at random. However, it does take some weevils to new fields. The importance of crawling as given by the same author is as follows:

> During the cold weather of spring and fall a day's journey of an adult weevil is only a few inches, but during the warm months the adults crawl through the greater part of the day or, in July and August, of the night. Although they use up much of their energy in climbing up and down plants, and into and out of crevices in the ground, so that it is largely wasted so far as progress is concerned, a little of it happens to lead to new fields. There is no general movement by crawling any more than by flight, from the fields to the ditch banks, fence rows, and similar places, or from such places to the field, at any time. This crawling is most important, as has been shown, in bringing weevils into hay, and so into traffic, which probably takes them somewhat further than they could go without help.

Hagan (1918) believes that the principal means of distribution into new territory is by flight. He states that in late summer the adult weevils take to wing to seek a shelter in which to pass the winter, and designates this as the summer flight. Although a comparatively large percentage of the weevils never leave the fields in which they have been feeding, those that do may travel several miles before hibernating. In the spring the overwintering adults appear and take their spring flight in search of food. He further writes that it is supposed that these two migrations enable the weevil to spread at the average rate of 20 miles a year; but careful study of weevil migration during the past few years has shown dispersal along favored routes to be much more rapid. Such an advantage as volunteer alfalfa along roadways, ditch banks, and railroad

tracks which furnishes food and shelter enable weevils to spread as far as 50 to 60 miles in a season.

Cook (1925) also reports a spring and summer flight of the weevil. He states that in early spring the adults emerge from hibernation and fly about actively seeking a place for oviposition. This he calls the spring flight. The summer flight occurs after the new generation appears from June to August.

Wakeland (1920) says:

> At one time it was hoped that barriers such as expanses of barren land might prove an effectual check to the natural spread of the insect and that it would not make progress rapidly against the wind. Both of these hopes were proven to be ill-founded. Newly infested fields were discovered to which the weevil could have spread only by flying across barren, adobe land at a distance of three or four miles and against the prevailing wind during the warm part of the day, when it is its habit to fly.

Snow (1925) states that flight and crawling of the adults, aided by the wind and the general traffic, have been the chief means of the slow spread of the weevil.

Reeves (1927*b*) reports the gradual spread of the insect around the edges of the infested district to be largely accomplished by unaided crawling and flight, which seem likely to carry the weevil wherever alfalfa is grown. Even the absence of growing alfalfa seems to be no hindrance to the spread, probably because of the large number of other plants upon which the weevil may feed. His findings are largely in accord with earlier investigations; in regard to a portion of the flight he says:

> The heat of the soil also probably accounts for a certain amount of flight by the adults during the dry, hot weather beginning in June and ending in August. This flight takes them to grassy and shaded places where they find protection from the heat. It also helps to restock fields in which the weevils have been killed, and on the borders of the infested districts it contributes to the spread of the pest. The flight is not a general movement of the weevils from the fields to seek more suitable hibernation places elsewhere. There is no such movement, and virtually all of the weevils spend the winter in the field.

Sweetman (1929) carried on some experiments in Wyoming, as follows:

> Screen wire covered with tanglefoot was placed 4 to 7 feet above the ground to entangle the adults while flying. No beetles were captured during May, June, and July in 1927, 1928, and 1929. . . . No evidence of flight to escape high temperatures or for other reasons was observed during May, June, and July in 1927, 1928, and 1929. Flights may take place in August and September as only a few observations have been made during these months.

He concluded from his results that if flight is considered a very im-

portant means of dispersal, the spread of the pest should be slow in Wyoming.

Henderson (1919) states that the weevils are rarely on the wing and that their distribution flight is almost negligible. He further cites some work carried out in the summer of 1914, by members of the United States Department of Agriculture Bureau of Entomology at Salt Lake City, in which a screen 4 x 40 feet was coated with tree tanglefoot and was erected in the midst of the worst alfalfa-weevil infestation in Utah. "During the season from March 25 to November 22, only 632 weevils were captured on a screen, having an area of 160 square feet, or fewer than 4 weevils per square foot for the season."

In this review of the literature on flight there are some conflicting reports. Many of these may be accounted for by the different conditions in the various locations where the investigations were conducted. Some of the work was published soon after the weevil made its first appearance and it is possible that there was not sufficient time for the workers to determine fully the importance and degree of flight.

NATURAL SPREAD IN CALIFORNIA

During the early stages of our investigation, which were started (June 1, 1932) in the San Francisco Bay area, the adult weevils in the field were observed only three times to be stimulated to flight, and on two occasions they were observed to fly only very short distances. These observations were made at Pleasanton, one in June, another on August 10, 1932, and the third on February 22, 1933. All days were clear and almost still. The temperature was about 70° to 75° F, in the first two cases and about 65° F in the third. How extensive flight may be under California conditions is still unknown, but it is likely that it plays an important part in the spread of the pest, for the individuals observed on February 22 appeared to be strong fliers. But later, when the weevil populations in the fields built up in larger numbers, flight became more apparent and, during June, 1933, considerable activity on the wing was noted. However, it should be pointed out that in certain areas, like the Livermore Valley and the district adjacent to Niles, there is a rather uniform occurrence of the beetle in all alfalfa fields, which can best be accounted for by natural flight, since in both districts the maximum distance covered is from 6 to 10 miles. Under certain conditions the weevil may be stimulated to fairly active flight. This is indicated by observation of adults in a field cage during November. On still, clear, warm days they were observed to become very active and to fly about freely at noon when the temperature was 70° F or above.

WIND AS A MEANS OF DISSEMINATION

The effect of the wind also enters into this phase of the discussion. The influence of air currents is closely interrelated with flight and has been touched upon under that subject. Webster (1912) states that the most rapid dispersion of the insect has been towards the northeast from the original point of infestation in the Salt Lake Valley. He says:

> [This northeastward trend of diffusion] must be considered in connection with prevailing southwest winds at the time when the beetles are flying, and, in fact, careful search over the newly infested territory seems to render it highly probable that to this cause is due this northeastward diffusion. The finding of individual larvae well scattered over Wyoming fields with little or no indications of introduction by human agencies, together with the finding of larvae in an irrigated valley, isolated from other cultivated crops by 35 miles of dry desert country, are conditions hard to explain in any other way than that the south winds of spring and summer have resulted in carrying flying beetles over low mountain ranges to fertile fields beyond. To just what extent the winds are able to carry the adults into new territory is not known, but at any rate migration in other directions has taken place much less rapidly.

Parks (1913) remarks that "thus far distribution appears to be almost entirely by flight and the wind has proved to be the main agency of dispersion by carrying beetles from infested fields to fields beyond the original area of infestation." He also states that the rate of dispersion must be influenced by the velocity and the direction of the wind during the time the beetles are on the wing. Titus (1913) reports that weevils have been taken as high as 9,500 feet in Salt Lake County. These had apparently been carried there partly by winds while they were flying and had lodged on the sides and summits of the mountains.

Reeves, Miles, *et al.* (1916) state that the greatest progress by the weevil has been made along certain wagon roads, rather than in the direction of prevailing winds, streams, or railroads. This point they illustrate by the road to St. Charles, Idaho, where the insect has gone 100 miles along the main road, across mountain ranges, regardless of prevailing winds, and far from railroads. In a later paper Reeves (1927*a*) remarks that there is no clear relation between the weevil travel and the prevailing winds. To this Sweetman (1929) adds that very little has been reported regarding the effects of wind on the alfalfa weevil and it is possible that air currents may aid the adults in flight but on the other hand may prove to be injurious to the larvae.

In the complicated conditions which govern the spread of the pest it is very difficult to say just how important any one of the factors may be. As conditions change, sometimes one, sometimes another, may appear to

be the most important. Unquestionably this leads to conflicting reports of results at times even when work is carefully done.

At the border of an infested region, it is difficult to determine what part of the spread is due to natural flight and crawling, and what part may be artificial. From our very limited experience it seems that the weevil could very easily and often be carried in fresh-cut hay to dairies and the like in the near vicinity of the border. It further seems certain that when beetles are numerous they might easily be carried considerable distances in clothing, etc. In other words, as an infested area extends, considerable farming and commercial intercourse may occur between infested and uninfested fields, which would offer the maximum opportunities for artificial spread.

ARTIFICIAL DISSEMINATION

Means of disseminating the alfalfa weevil has been a much debated subject, and many quarantine measures against the pest have at times been enacted which were intended to prevent or check its advance. There are many means by which it can be transported, and under some favorable conditions it can probably be carried long distances and remain alive for rather long periods. If this were not the case it is doubtful whether it would ever have been introduced into Utah from Europe. Of the many ways by which it can be carried, most are probably unfavorable to the beetle, and further if the pest should survive transportation it would be necessary for it to escape in the neighborhood of one of its hosts in order to become established. The weevil unquestionably has often been artificially carried far and wide, but the chances of its gaining a foothold are rather small, and since its introduction into Utah it has made only a few long jumps of this character. Evidence that the weevil is freely transported is given by the following statement, which is taken from the Weekly News Letter of the California State Department of Agriculture (1924):

> During the month of June [1924] many live alfalfa weevils, were taken from automobiles. As many as 140 live weevils were shaken from the camping equipment of a single car. In one case 40 live weevils were intercepted in a small quantity of green alfalfa hay which a camper had gathered in Nevada. Interceptions of from one to a dozen or more alfalfa weevils in a live condition are daily occurrences at the border stations.

Alfalfa meal has been suspected as a commodity which might be of importance in spreading the weevil. However, there seems to be little danger of this where alfalfa is milled under proper conditions. Dean (1932) reports that certain types of mills are fatal to the alfalfa weevil;

when the latter are passed through the entire milling process, it was demonstrated upon careful examination of the resultant product that the insects were entirely destroyed. Reeves, Hawley, *et al.* (1932) substantiate Dean's findings and further state that by intensive examinations of all parts of mill premises, it is established that few weevils even reach the premises. Of those found about the mill all were in such locations as to constitute little if any menace in recontamination of the meal prior to shipment. However, even this slight chance could readily be eliminated by the construction of screened runways between sacker and railway car. Any hazard from weevil-contaminated sacks could be prevented efficiently and economically by sterilization of the sacks before use. Thus the conditions are such that alfalfa meal is, or can readily be rendered, no more important in the spread of alfalfa weevil than any other class of merchandise, and may be moved during all months of the year with equal safety. In conclusion it is pointed out that there appears to be no reason, in the interest of preventing weevil spread, why alfalfa meal should be restricted more than other weevil-free merchandise.

In the examination of alfalfa mills Reeves (1930*b*) reports the finding of but 24 live weevils in one, and 20 live weevils in another, all of which were found in the receiving rooms and none in the finished product or the shipping rooms of the mills. This amounted to the finding of one weevil to each 5.8 hours of search in the first mill and to each 7.75 hours in the other and indicates the entire absence of the much discussed tendency of weevils to accumulate at mills.

Larrimer and Reeves (1929) reach the conclusion that the large number of weevils present in the growing crop diminishes with each step in the handling of the hay so that the accumulation on the premises of an alfalfa-meal mill, even at the end of the summer, is negligible; and the only source of contamination in the mills, generally speaking, is the hay which is being ground. They further state that in certain mills it was possible for weevils to pass through the machine alive but that this condition was easily remedied, so that meal could be delivered uninfested at the door of the freight car. It is also pointed out that cars which have been used for infested alfalfa hay, remain infested for an indefinite time thereafter, and that these cars, and not the alfalfa meal, constitute the real danger; and it is remarked that these cars are used more frequently for other commodities than for alfalfa meal.

Hawley (1932) found that after weevils have been in a haystack through the winter months it is difficult to find any of them alive in the spring and of course there would be little danger of contamination in alfalfa meal made of such hay.

There is apparently no danger of spreading the weevil in alfalfa-seed shipments. Titus (1910*a*) first called attention to this fact, and Parks (1913) substantiated his findings. Reeves, Miles, *et al.* (1916) state that live weevils do not occur in alfalfa seed, either before or after it is recleaned. Henderson (1919) also cites data which show conclusively that there is no danger of carrying the pest in alfalfa seed.

While neither alfalfa meal nor seed seem to be of importance in the spread of the weevil, alfalfa hay at times may play an important part in its distribution.

Titus (1909*b*) reports that where animals are being shipped from the country, for instance at the time of such events as a state fair, abundant opportunity may be given for the insect to pass to some other uninfested district or even out of the state. "The hauling of hay from one part of the state to the other, and the carrying of feed for horses, sheep, and stock, by persons driving through an infested region, will materially aid in the distribution of the insect." He states that this has been especially true of the weevil distribution in the Summit County region of Utah. In another paper he states:

> While the crop is being put up, weevils are often so numerous that men working in the fields are made decidedly uncomfortable by weevils crawling outside and inside their clothing, over their faces, and in their hair, and where the hay from the fields is being put in barns, one side of a barn may at times be almost covered with adults. Later in the winter or in the early spring, when the last of this hay is being fed out, the floor of the barn will often be swarming with beetles which have passed the winter in this well-protected place. (Titus, 1910*a*.)

However, the investigations of Hawley (1932), already mentioned, have shown that but a few of the weevils survive the winter out of doors in the stacks. He found that of the many weevils which collect around the bottom of the hay stacks, only a few were alive the following spring because of the wet and decomposed condition that obtains around the bottom of overwintering stacks. He further observes that in the upper part of the stacks the mortality in the hay samples examined ranged from 91 to 98 per cent and reports that weevils live readily for one month in baled hay, and a few may live for two months, but none can survive several months.

Reeves, Miles, *et al.* (1916) state:

> Another important consideration as to the occurrence of the weevils in new hay is that many people driving through the country in summer carry it for short distances as feed for their horses. The weevils may leave the hay as a result of the jar of travel, according to their habit; and that they do so is the more probable because no colonies have been found at any distance from the main territory, as would have happened if they were carried long distances by wagon. There is,

however, a constant stream of traffic over certain main roads, composed of sheepmen, peddlers, and others bent on business or social visits to other localities, near or remote. The carrying of weevils by these people, even if it be but for a mile or two, amounts in the aggregate to a systematic relaying of the species over through routes. There seems, in fact, to be a relation between the localities where alfalfa from infested fields is carried in this way and the country over which the weevils have spread most rapidly.

Again Reeves (1917) reports that nearly every case of the occurrence of the weevils in commerce has been traced to actual contact of the commodity with infested alfalfa hay. Weevils are found in hay hauled in wagons, in certain cars of potatoes, and in clothing worn upon trains and carried in trunks. In a later paper (Reeves, 1927*a*) he reports that the occurrence of the weevil upon farm produce can usually be traced to the handling of the latter in contact with freshly cut alfalfa. Again in 1930 he carried on investigations which showed that relatively few of the weevils which are so abundant in the fields ever reach the stack, and those which do so perish for the most part before the hay is removed from the stack, and that baling kills most of the rest (Reeves, 1930*a*).

From the studies of Reeves and Hawley, it appears that there is little danger of the weevil's being spread in alfalfa hay which has remained in the field throughout the winter.

Webster (1912) points out an interesting case in which hay was shipped from an infested territory into an uninfested area without the weevil's becoming established. He states that for a considerable time after the weevil became abundant about Salt Lake and Murray, hay was shipped from these points to Ely, Nevada. This occurred in the midst of the season, when it would seem impossible to transport hay from these points to its destination without carrying a greater or lesser number of the weevils. Notwithstanding this, years have gone by, and during the summer of 1911, two assistants examined the country about Ely most carefully without finding a single alfalfa weevil or any indication that it had ever existed there.

Potatoes and the alfalfa weevil are often associated together. This seems to be the result of farmers' handling their potatoes along with infested alfalfa. Thus Henderson (1919) states: "The only known means by which alfalfa weevil can be transported is in alfalfa hay or on objects contaminated only by alfalfa hay, particularly potatoes which have been brought to market in conveyances bedded with alfalfa hay." Reeves, Miles, *et al.* (1916) say that the occurrence of weevils in green alfalfa hay and new hay of the second crop is particularly important because potatoes which are to be shipped are often hauled to the car upon a bedding of it to prevent bruising and are sometimes covered with

it for protection from the sun. This hay when from infested districts, often contains weevils, which crawl from the alfalfa to the sacks and are loaded into the tight refrigerator car, in which they often remain until it reaches its destination. Although no colonies are known to have been started by this means, there is constant danger of it, which can be minimized by simply keeping the hay away from the potatoes. Weldon (1916) also points out the danger of the pest's gaining entrance to sacks of potatoes, and states that a number of weevils have been taken from potato cars in Montana. He suggested that before shipping, potatoes should be screened and transferred to clean sacks.

Titus (1910*a*) reports that many fruit orchards are partly surrounded by alfalfa and that migrating weevils from these often crawl into the fruit packages which are being shipped to other sections of the state or to other states. Weldon (1916) points out that emigrants moving from an alfalfa-weevil-infested state are apt to use hay, or other material containing alfalfa weevils, in packing goods or cars. Newton (1926*a*) states that the problem of the tourist and the transient laborer during the harvest season, and the movement of farm products, all represent just a part of the many artificial factors contributing to the dissemination of the pest.

Just what part the railroads have played in the spread of the weevil is a question. As there have been only a very few long jumps made by the insect it would appear that they have played only a minor role. Parks (1913) states that railway trains are particularly apt to carry the beetles during the time they are flying, but has thus far found no new areas of infestation that can be attributed to this or any other artificial agencies of dispersion. Titus (1910*a*) reports that it is not uncommon, during the flying season, to find weevils in cars on the railroad trains which are passing out of Salt Lake Valley into other valleys. Weevils flying against these trains cling there and may not drop off for several miles. If the locality where they leave the train is favorable for their hibernation or breeding, a small colony may easily be started. Weevils that get inside of cars may be carried for almost any distance. Twenty-seven were taken in the vestibule of one sleeping car on a train in Salt Lake County one day in July, 1910. Titus (1913) remarks that although many specimens of weevils have been carried out of the infested area by train, to that date no colonies were found that could be certainly attributed to this cause alone.

Reeves, Miles, *et al.* (1916) report that if railroad trains have carried the weevils, it has evidently been only for short distances. It is further stated that no connection can be traced between the railroads and the

actual spread of the alfalfa weevil; in fact, the advance of the weevils has been rather less rapid along some railroads than in certain regions remote from them. The weevils occur rarely in baggage, express, and freight cars, but somewhat more often in passenger cars and refrigerator cars containing potatoes which have been handled with fresh second-crop alfalfa hay. Their investigations have also shown that the transportation of the weevils on railroad trains and wagons is little affected by the flying of the species. It seemed reasonable at an early period of the investigation to believe that a beetle which flies abroad in the summer would alight upon various commodities and vehicles and be carried for great distances, but such is not the fact. Weevils are rarely found on trains or wagons except in cases where new hay is involved.

Reeves (1930*a*) states that over 2,000 cars are used each year for the shipping of infested hay, and that these cars are dispersed rapidly into every corner of the United States. He carried on investigations which showed that 15 per cent of the weevils remained alive in the car during a 5-day trip, and 40 per cent of them during a 3-day trip, and points out that these car histories are ominous. Again Reeves, Hawley, *et al.* (1932), in their study on the alfalfa-meal quarantine in relation to the spread of the weevil, state that from the point of view of preventing future spread of the pest it is their opinion that the movement of empty hay cars infested with living weevils constitutes a far greater menace than any other factor which has come under their study, and that railway cars assuredly free from weevils cannot be had at the present time. Larrimer and Reeves (1929) substantiate the above and in their paper report that freight cars which have been used for infested alfalfa hay remain infested for an indefinite time.

H. S. Smith (1917) points out that during the first 13 years the pest had existed in America up to 1917, not a single long jump had occurred in its distribution. Even in the infested states he reports that the pest had not traveled more rapidly along the railroads than elsewhere, although the adult beetles had been taken countless times from Pullman and freight cars.

On the other hand, there is some almost positive proof that railroads have played a role in the spread of the weevil. Certainly it seems that it must have been first carried to Utah by train from the seaboard. Further, the infestation in middle California was probably started by weevils brought in by the railroad.

There is some evidence that the weevil is carried by water, but this means of spread seems to be of but little importance. Titus (1909*b*) reports that weevils fall into irrigation ditches and are swept onward,

and at times into a field, where they may secure lodgment on leaves or stems of the plants. Once they obtain solid footing they go on until they reach a field where food plants are present or until night drives them to shelter. Webster (1912) states that the weevil appears to float about freely on the surface of water, and is doubtless carried long distances down stream by the current. This is true in the case of irrigating ditches and canals. List and Wakeland (1919), working in Colorado, showed that the adult weevils are able to live in water for fairly long periods, and point out the apparent danger of their being spread in irrigation water to uninfested fields. However, in the following year, Wakeland (1920) reports that scouting disclosed the fact that the weevil had in a year's time, spread over such a large territory by flying that its dissemination by means of irrigation water is relatively unimportant as far as adjacent territory in Colorado is concerned. Newton (1926*a*) remarks that even though it has been demonstrated that irrigation waters carry the insect down stream, the most rapid spread has often been up stream. One particular case in mind is that of a number of fields which have not become infested even though they are continually irrigated from a ditch that flows through an infested area on a mesa, or tableland, above. Reeves (1927*b*) also points out that the weevil is known to be carried by irrigation canals, and presumably by rivers.

NATURAL ENEMIES

In Asia and Europe there are a number of natural enemies which attack the alfalfa weevil. These consist of two main groups: animals and fungi. Of the animals, insects are the most important because they are more abundant in species and numbers and more specific in their host requirements. Birds and certain small insectivorous mammals also play a part in the reduction of the numbers of the weevils in the fields. Among the fungi which subsist on this, and other insects, are the entomophthorales which may attack the different stages of the weevil.

Certain of the insect parasites have been introduced into the United States by the United States Department of Agriculture Bureau of Entomology and have become established in the infested alfalfa fields of the Great Basin.

It does not seem desirable to enter into a lengthy discussion of all of these natural enemies here, especially of those not present in this country, but a brief summary of the latter is given, with a fuller treatment of those established in this country.

Insects which actually devour the larvae and adults of the alfalfa weevil are numerous, but because they are usually general feeders and

do not confine their feeding to this particular pest, their effectiveness in reducing the numbers of the weevil is of little concern. Therefore, the predators have not been carefully studied and the published reports concerning them are meager, both in this country and in Europe. The following list will serve to give some idea of the groups of predators that might be expected to destroy the weevil wherever it occurs.

MITES

The ventricose mite, *Pediculoides ventricosus* (Newport), has been observed to destroy the eggs of the alfalfa weevil in alfalfa fields in Utah and specimens were even introduced into the fields, although the mite was later found to occur in the region (Webster, 1912). This noxious mite is almost cosmopolitan in distribution. It also attacks the miniature stages of various hymenopterous parasites, other insects, and even man, and is therefore hardly to be considered as an an adjunct of any importance in the control of the alfalfa weevil.

The red predacious mite, *Erythraeus arvensis* Banks, has been observed feeding on the eggs of the alfalfa weevil in Utah (Webster, 1912).

INSECT PREDATORS

Tiger Beetles, Family Cicindelidae.—The adults of the imperfect tiger beetle, *Cicindela imperfecta* Lec., have been observed feeding on the alfalfa weevil larvae in Utah (Webster, 1912). This beetle also occurs in Texas, Utah, Nevada, California, Oregon, and Washington (Leng, 1920).

Ladybird Beetles, Family Coccinellidae.—The convergent ladybird beetle, *Hippodamia convergens* Guerin, has been observed to attack the alfalfa weevil. In Utah the larvae of the ladybird have been recorded as feeding on the larvae of the weevil (Webster, 1912) and in California we have seen the adult ladybird fiercely attack and devour the young larvae of the alfalfa weevil. How much good they do in destroying the pest is not known. This beetle occurs throughout the entire United States and is especially abundant in the western states.

A related species, *Hippodamia sinuata* Muls. var. *spuria* Lec., has also been recorded as feeding in the larval stage on the larvae of the weevil (Webster, 1912). This ladybird beetle occurs throughout the Rocky Mountain region and the western states.

The nine-spotted ladybird, *Coccinella 9-notata* Hbst., has habits similar to the other two species; the larvae and also the adults attacking the larvae of the weevil (Webster, 1912). It occurs throughout much of the United States, but does not appear to be numerous in any large area.

Soft-winged Flower Beetles, Family Melyridae.—The two-spotted collops, *Collops bipunctatus* Say, feeds in the adult stage on the alfalfa weevil in Utah (Webster, 1912). It ranges from Kansas to California.

Darkling Ground Beetles, Family Tenebrionidae.—Adults of the darkling ground beetle, *Eleodes sulcipennis* Mann., are recorded by Webster (1912) as feeding on the larvae of the alfalfa weevil in Utah. The insect is also known to occur in Idaho, northern California, Oregon, and Vancouver.

INSECT PARASITES

Among the most important natural enemies of the alfalfa weevil are the insect parasites, of which there are a number attacking the eggs, larvae, prepupae, and pupae. These parasites are for the most part small or minute, active, winged insects of the order Hymenoptera. They lay their eggs in or on the host and the larvae feed inside or on the exterior and eventually completely destroy the particular stage of the weevil attacked. All of the known parasites of the alfalfa weevil are of Old World origin. Of the many studied in Europe and subsequently introduced into this country, only two species have been established in the alfalfa-weevil-infested fields of the Great Basin and in Nevada.

Usually much more is expected and claimed of the larval parasites than can be gained in a practical way. The alfalfa weevil is greatly affected by climatic conditions, as is shown elsewhere in this paper, and the sudden reduction of the pest because of unfavorable weather is often wrongly ascribed to the work of parasites, the activities of which are difficult to observe and the actual efficacy of which is not accurately known. Concerning the efficacy of *Bathyplectes curculionis* on weevil increase and control, Chamberlin (1924) makes this statement:

> Before parasites become numerous, it was observed that for several years after the weevil is first noticed in any locality it increases at a tremendous rate, but that after the third or fourth year the insect is apparently taken under control by natural influences and ceases to increase. According to egg-laying records of weevils kept in the laboratory, the potential annual increase is not far from 400 to 1. It follows that natural control depends upon the removal in one way or another of about 99.8 per cent of the females of each generation. Unfortunately, before this condition is attained, the weevils are numerous enough to produce destructive numbers of larvae.
>
> These natural controlling factors include winter killing and summer killing, and it is largely because of the latter that the effect of this parasite (*Bathyplectes* [*curculionis*]) upon the reproduction of the weevil is greatly reduced. The summer killing in large part takes place at the time of the cutting of the first crop, when larvae are exposed to the hot dust, and in hot and dry weather about 90 per cent are removed in this way. This mortality is independent of the parasites and takes place just as surely without as with them, and their work is largely wasted upon

victims that would not produce offspring in any event. This goes far to explain why *Bathyplectes* can destroy 90 per cent of the larvae year after year without causing any marked decrease in the numbers of the pest. Considering this fact, together with the continued feeding of parasitized larvae and the recent weather conditions, there may still be doubt, in spite of the great numbers of existing parasites, that these have caused the improvement in the crop which has generally

TABLE 8

LIST OF HYMENOPTEROUS PARASITES ARRANGED ACCORDING TO THE VARIOUS STAGES OF THE HOST*

Reared from eggs of the alfalfa weevil	Reared from larvae of the alfalfa weevil
Anaphoidea luna Gir. (*Anaphes* sp.)	*Adelognathus* sp.
Eupelminus excavatus (Dalm.)	*Bathyplectes corvina* (Thoms.)
Peridesmia phytonomi Gahan ("Pteromalid A")	*Bathyplectes curculionis* (Thoms.)
Spintherus sp. ("Pteromalid B")	*Bathyplectes tristis* (Grav.)
	Stenocryptus nigriventris Thoms.
	Tetrastichus sp.
	Tetrastichus incertus (Ratz.)

Reared from cocoons—prepupae and pupae—of the alfalfa weevil	Reared from alfalfa-weevil material; stage of host unknown
Aenoplegimorpha micator (Grav.)	*Eutelus* sp.
Dibrachoides dynastes (Förster)	*Eulophus* sp.; may be a secondary
Hemiteles graculus (Grav.)	
Hemiteles hemipterus (Fab.) (secondary?)	
Necremnus leucarthros (Nees)	
Pimpla maculator (Fab.)	
Spilocryptus pumilus Kreich.	

* A single dipterous parasite, *Tachina impotens* Rondani, was reared from a larva of the alfalfa weevil in France (Thompson, 1920). The various hymenopterous parasites are more fully discussed in their proper families in the following pages.

been credited to them. When circumstances favor development of the weevils rather than the alfalfa, and the insect is permitted by climatic conditions to develop its attack as formerly, the value of the parasites will be subjected to a true test. *Until then they must be counted a potential safeguard to be studied with a view to increasing their usefulness, while other means are relied upon to protect the crop.*

In discussing the alfalfa weevil with reference to its environment, Reeves and Hamlin (1931*a*), make this significant statement concerning the effects of parasitism on the control of the pest: "We dealt with such anomalies as a parasitism of 99 per cent which still failed to control the host; and a host with an enormous rate of multiplication whose numbers were still apparently self-limited after the first few years in a given locality."

Although ten species of parasites of the alfalfa weevil were liberated in Utah (Reeves, 1927*a*), only two have been established in the Great Basin. It is expected, however, that others might be acclimated in the newly infested districts of California, particularly parasites of the eggs and larvae of the weevil. As a matter of fact some of these new parasites are already being introduced through a coöperative project between the California Agricultural Experiment Station and the United States Department of Agriculture Bureau of Entomology. Because of this new interest in the parasites, we are listing all of the known species observed in the Old World, together with such available information as may be useful to those concerned with the alfalfa weevil in California and elsewhere.

Adelognathus sp., Family Ichneumonidae.

This insect is listed as a parasite on the larvae of the alfalfa weevil in Poland by Krasucki (1925).

Aenoplegimorpha micator (Gravenhorst), Family Ichneumonidae; (Chamberlin, 1924*a*).

Ichneumon micator Gravenhorst (1807), (Dalla Torre, 1891).
Hemiteles micator Gravenhorst (1829), (Dalla Torre, 1891).
Aenoplegimorpha phytonomi Viereck (1912), (Cushman, 1922).

This parasite is listed as occurring throughout Europe. It was introduced into and established in Utah, but is not important as a parasite of the prepupae and pupae of the alfalfa weevil. Chamberlin (1924*a*, 1924*b*). A single specimen was reared from the cocoon within the cocoon of the alfalfa weevil taken at Hoytsville, Utah, 1911, Webster (1912), and was described as a new species, *Aenoplegimorpha phytonomi* by Viereck (1912). This proved to be identical with the European *A. micator* (Grav.) (Cushman, 1922).

Bathyplectes corvina (Thomson), Family Ichneumonidae; (Chamberlin, 1924*a*).

Canidia corvina Thomson (1887), (Dalla Torre, 1891).
Canidiella corvina (Thomson), (Dalla Torre, 1891).

Bathyplectes corvina is parasitic on the larvae of the alfalfa weevil. This species, which is similar in habits to, and coextensive with, *B. curculionis* (Thomson), is found practically throughout the range of the alfalfa weevil in Europe, having been noted as *Canidiella curculionis* (Thoms.) in Kuban, Russia, by Grossheim (1913); in Sweden and Germany by European entomologists (Dalla Torre, 1891); and in southern Europe by Chamberlin (1924*b*).

According to Chamberlin (1924*b*) it is one of the most promising

parasites of the alfalfa weevil in Europe and may be the dominant one in some localities, as at Hyères, France, in 1922 and 1923.

It normally pupates in the fall and passes the winter either in the pupal or in the adult stage within a cocoon and issues in the spring. It has but one generation a year. It is difficult to handle in confinement and was never established in this country.



Fig. 13.—*Bathyplectes curculionis* (Thomson), an introduced parasite of the larva of the alfalfa weevil: adult female with lateral view of the abdomen at right. (After Webster, U. S. Department of Agriculture, Bureau of Entomology, 1912.)

Bathyplectes curculionis (Thomson), Family Ichneumonidae; (Chamberlin, 1924*a*).

Canidia curculionis Thomson (1887), (Dalla Torre, 1891).
C. subcincta Holmgren (1858), (Dalla Torre, 1891).
Canidiella curculionis Thomson, (Dalla Torre, 1891).

This is an internal parasite (figs. 13 and 14) of the larvae of the alfalfa weevil. It is the only important parasite of the alfalfa weevil established in this country and has had a rather remarkable development in the Great Basin.

Adults issue from overwintering cocoons of the host in spring and oviposit in larvae of the host. The development from egg to full-grown larvae requires about two weeks. Full-grown larvae issue from the prepupal larvae of the weevil after the cocoons of the latter are spun and make their own cocoons within that of the alfalfa weevil. Adults issue from the cocoons in about two weeks and oviposit in weevil pre-



Fig. 14.—*Bathyplectes curculionis* (Thomson), the parasite of the larva of the alfalfa weevil, and cocoons. The latter are chocolate brown with a pale band. They occur in the cocoons of the weevil. This parasite has been recently introduced into California. (Courtesy California State Department of Agriculture.)

pupal larvae of the same generation; at this time the weevil larvae are most abundant. The cocoons of the second generation parasites are usually darker and thicker than those of the first generation, being from a medium-brown to chocolate-brown color with a distinct whitish band around the middle. Most of the second-generation parasites remain in their cocoons as prepupal larvae until the next spring, when they pupate and issue as adults (Chamberlin, 1924*a*).

It is widely distributed in the Old World, being recorded in Boreal and central Europe by Dalla Torre (1891), in Germany, Switzerland, France, Italy, and Sicily, by Martelli (1911); in Kuban, southern Russia, by Grossheim (1913); in Tunisia, northern Africa, by Chamberlin (1926); and in Turkestan, Asia, by Dvornitchenko (1917).

After a study of the parasite in southern Europe, shipments of cocoons and parasitized larvae of the alfalfa weevil were made to America by W. F. Fiske in 1911, H. S. Smith in 1912, and W. R. Thompson in 1912 and 1913. Those sent over by Thompson were mostly from Switzerland. The material was shipped in screen cans in cold storage.

TABLE 9

SUMMARY OF THE ECONOMIC RECORD OF *Bathyplectes curculionis* IN THE UNITED STATES

State	Year	Introduction, and percentage of parasitism found	Authority
Utah	1911–1914	Introduced from Europe	Chamberlin (1926)
	1914	Present in fields—scarce	
	1916	From 2 per cent to 30 per cent	
	1919–1920	Often exceeded 90 per cent	
	1924	From 29.9 per cent to 84.5 per cent	
	1925	From 8 per cent to 97.3 per cent	
Idaho	1919	Abundant at Paris, Idaho; spread naturally from Utah	Chamberlin (1926)
	1920	Present at Ashton	
	1924	Reached 25 per cent	Idaho Agr. Exp. Sta. (1925)
	1925	Reached 50 per cent	Idaho Agr. Exp. Sta. (1926)
Colorado	1918	Introduced from Utah	Chamberlin (1924*a*)
	1919	Additional introductions	Newton (1921)
	1920	From 1 per cent to 30 per cent	
	1922	About 50 per cent	Newton (1923)
	1923	As high as 60 per cent	Newton (1924)
	1924	From 25 per cent to 89 per cent	Newton (1925)
	1925	From 40 per cent to 60 per cent	Newton (1926*a*)
	1926	During 8 years the parasite spread at the rate of 6 miles per year	Newton (1926*b*)
Nevada	1921	Introduced from Utah	Chamberlin (1924*a*)
	1922	Introduced from Utah	Doten (1928)
	1925	Parasite throughout weevil-infested area	Snow (1925)
California	1933	First introduced into central part	

Only about 50 per cent of the primary parasites subsequently issued and secondary parasites issued in confinement from between 24 and 65 per cent of the cocoons.

In 1911, 40 adults of this parasite were liberated in field cages in the weevil-infested alfalfa fields near Sandy, Utah, and later the cages were opened to allow them to escape into the fields. In 1912, 48 males and 121 females were liberated directly in the fields. In 1913 and 1914, 1,335 parasites were liberated in the alfalfa fields at Ogden, Kaysville, and Salt Lake City, Utah—all of which were from the 1913 importations. Other liberations followed in 1914, bringing the total number liberated

to 1,544, a rather small number considering the rapid subsequent spread of the insect. In view of the difficulties and failures in establishing other parasites of the alfalfa weevil in Utah, the colonization of this one was easy and the natural increase and diffusion was rapid. In 1914, the first field recovery of small numbers of adults was made near Sandy, where the first liberations were made. It was also found in considerable numbers at Murray and Salt Lake City. By 1916 it had dispersed along the eastern side of the Salt Lake Valley to a distance of 8 or more miles and an examination of 3,000 weevil cocoons showed a parasitism of 22.5 per cent. It was also found in Weber Valley, 30 miles east of Salt Lake City, where the parasitism ranged from 2 per cent to 30 per cent, and at Kaysville and Ogden. In 1917 the parasite had reached Praco, 35 miles from Salt Lake City, and by 1918 it had reached Brigham City, 50 miles distant. In 1919 the parasite spread as far as Salina, Utah, 120 miles south of Salt Lake City, and to Paris, Idaho, 95 miles north. By 1920 it was found at a maximum distance of about 230 miles from Salt Lake City and occurred in Idaho, Wyoming, and in eastern, western, and southern Utah. It spread 196 miles from Ogden, Utah, to Ashton, Idaho, in six years during the period from 1914 to 1920, and 230 miles in eight years, which shows the great power of flight and the very rapid dispersal of the parasite. No definite additional recent figures on this matter are available. See table 9.

Observations by various workers concerning the increase, spread, and effectiveness of *Bathyplectes curculionis* are given below:

> The parasite, *Bathyplectes curculionis,* has increased in numbers until it now [1924] actually swarms in the infested fields of Utah and destroys over 90 per cent of the weevil larvae in the older sections, much surpassing its effectiveness in any of the localities studied in Europe at the time of the importations, where the highest local average of parasitism by all species of parasites which attack the larvae was 12.5 per cent. [Chamberlin, 1924*a*.]

> *Bathyplectes* does not appear present in the fields to parasitize the larvae heavily at all periods of the year, a fact which leads one to suppose that its work might well be supplemented by a many-brooded larval parasite, which would work late into the season. [Chamberlin, 1926.]

> It is believed that this parasite must destroy enormous numbers of the weevils, but the effect is so long delayed (until the breeding season of the following year), and the rate of increase of the weevil is so rapid, that the practical value of this parasitism is not yet certain. Intermittent and unforseeable control of the pest might do as much harm as good; it would still be necessary for the farmer to carry the overhead expense of spraying for the weevil, and he would often be deluded by a false feeling of security into neglecting preparations for weevil control, and consequently lose his crop. [Reeves, 1927*b*.]

In the course of the fiscal year it became evident that the introduction of the parasites of the alfalfa weevil by the Station in 1922 had been effective in finally bringing about a reduction in the destructiveness of the pest; but not as yet to the extent of making spraying or dusting of the fields unnecessary. [Doten, 1929.]

It has been discovered that an overwhelming percentage of parasitism may be completely offset in its economic effect by weather conditions. [Reeves, 1930.]

Authorities agree that the *Bathyplectes* parasite is often abundant in the infested fields and reduces the numbers of the weevil larvae materially, but it does not appear to be a real economic factor in the actual control of the pest.

This parasite was introduced into the alfalfa-infested fields in California by the United States Department of Agriculture Bureau of Entomology during the summer of 1933.

Secondary parasites of *Bathyplectes* spp. in Europe are given by Chamberlin (1924*a*, 1924*b*) as: *Mesochorus nigripes* Ratz., *Gelis stevenii* (Grav.), *Dibrachys boucheanus* Ratz., and *Eupteromalus* sp. The first of these secondaries, *Mesochorus nigripes* Ratzeburg (1852), has also been listed as a parasite of the larvae of the alfalfa weevil in Poland by Krasucki (1925).

Bathyplectes tristis (Gravenhorst), Family Ichneumonidae; (Chamberlin, 1924*a*).

Campoplex tristis Gravenhorst (1829), (Dalla Torre, 1891).
Limneria tristis Marshall (1872), (Dalla Torre, 1891).
Canidia tristis Brischke (1880), (Dalla Torre, 1891).
Canidiella tristis Gravenhorst, (Dalla Torre, 1891).

This is an internal parasite of the larvae of the alfalfa weevil and the clover leaf weevil. It is rather scarce and has probably but one generation a year.

It has been recorded in Great Britain and Germany without reference to hosts by Dalla Torre (1891) and in southern Europe, on the abovementioned alfalfa-weevil hosts, by Chamberlin (1924*b*).

Hemiteles graculus (Gravenhorst), Family Ichneumonidae; (Chamberlin, 1924*a*).

Bassus graculus Gravenhorst (1829), (Dalla Torre, 1891).

Hemiteles graculus is an unimportant parasite of the alfalfa weevil and the only member of the Cryptinae found in any considerable numbers in Italy (Chamberlin, 1924*b*). Dalla Torre (1891) also lists it from Great Britain without reference to hosts. It apparently oviposits in the prepupae only.

Hemiteles (*Aptesis*) *hemipterus* (Fabr.), Family Ichneumonidae; (Cushman, 1927).

Ichneumon hemipterus Fabricius (1793), (Dalla Torre, 1891).
Hemiteles insignipennis Schmiedeknecht (1905), (Cushman, 1927).

This parasite has been reared from the cocoons of the alfalfa weevil collected in southern Europe and has been recorded from Germany by Schmiedeknecht (1905). It has also been reared as a hyperparasite of *Microgaster tibialis* Nees and *Eulimneria crassifemur* (Thomson), primary parasites of the European corn borer, *Pyrausta nubilalis* Hbn. (Cushman, 1927).

Pimpla maculator (Fabricius), Family Ichneumonidae; (Escherich, 1931).

Itoplectis maculator (Fab.), (Chamberlin, 1924*a*).
Ichneumon maculator Fabricius (1775), (Dalla Torre, 1891).
Pimpla maculator Gravenhorst (1818), (Dalla Torre, 1891).

This is an internal parasite of the prepupae and pupae of *Phytonomus* spp. as reported by Chamberlin (1924*b*) and also noted on the immature stages of many moths and other insects in Europe. The adults oviposit through the cocoons of the hosts.

This species is recorded as occurring throughout the continent of Europe by Dalla Torre (1891), who lists as hosts twelve species of Lepidoptera, one species of Hymenoptera, and one undetermined Arachnida. Escherich (1931) also lists two species of Lepidoptera, one of which is included in those by Dalla Torre.

It is recorded as a parasite of the alfalfa weevil in southern Europe—France and Italy—by Chamberlin (1924*b*), in France by Picard (1914*a*), and in Russia by Grossheim (1913).

A secondary pteromalid parasite, *Catolaccus ater* Ratz., is thought to attack *Pimpla maculator* (Chamberlin, 1924*b*).

Spilocryptus pumilus Kreichbaumer (1899), Family Ichneumonidae; (Chamberlin, 1924*a;* Dalla Torre, 1891).

This parasite, which is apparently of little importance, was noted on the prepupae and pupae of the alfalfa weevil in Italy by Chamberlin (1924*a*) and was also recorded in Tyrol by Dalla Torre (1891). The life cycle is 17 days.

Stenocryptus nigriventris Thomson (1873), Family Ichneumonidae; (Krasucki, 1925).

Pammachus nigriventris (Thomson), (Dalla Torre, 1891).

This larval parasite of the alfalfa weevil was noted in Poland by Krasucki (1925) and listed in Boreal and central Europe by Dalla Torre (1891).

Necremnus leucarthros (Nees), Family Eulophidae; (Chamberlin, 1924*b*).

Eulophus leucarthrus Nees ab Esenbeck (1834), Dalla Torre, 1898).
Necremnus leucarthros Thomson (1878), (Dalla Torre, 1898).

This is an external parasite on the prepupae of the alfalfa weevil with habits similar to those of *Dibrachoides dynastes* (Förster). The eggs are laid externally on the host, as many as 41 being deposited upon a single prepupa in the laboratory. Only a few of these mature, but 18 adults have been reared from a single prepupa of the alfalfa weevil. It is one of the most promising weevil parasites in Europe, although it is found only in fair numbers there. It was collected in France and Italy by Chamberlin (1924*b*, 1925*b*) and reported in Germany by Nees (1834) and in Sweden by Dalla Torre (1898).

This parasite has also been observed to attack the immature stages of the chrysomelid beetle, *Lema cyanella* Linn., in Moravia (Ruschka and Fulmek, 1915; Chamberlin, 1925*b*).

Eulophus sp., Family Eulophidae.

Such an undetermined species is recorded as a parasite of the alfalfa weevil by Martelli (1911).

Eupelminus excavatus (Dalman), Family Eupelmidae; (Chamberlin, 1924*a*).

Eupelmus excavatus Dalman (1820), (Dalla Torre, 1898).

This is an external feeder on the eggs of the alfalfa weevil and the clover leaf weevil. Normally the larvae estivate in the stems of alfalfa plants and the adults issue in autumn. It is recorded by Dalla Torre (1898) in Great Britain and Sweden, and by Chamberlin (1924*a*, 1924*b*) in France, Italy, and Sicily.

Although introduced into Utah in 1913, this parasite apparently never became established there.

Anaphoidea luna Girault (1914), Family Mymaridae.

Anaphes sp.

This is a minute egg parasite (fig. 15) of the alfalfa weevil which is known to occur in France, Italy (Silvestri, 1915), and Sicily (Chamberlin, 1924*a*), where it also parasitizes the eggs of the clover leaf weevil, *Phytonomus punctatus* (Fabr.). This insect is particularly effective in destroying the eggs of the weevils deposited in dry stems.

According to Chamberlin (1924*b*) it places two eggs in each of the eggs of the clover leaf weevil and one in each of the eggs of the alfalfa weevil, which are smaller than those of the clover leaf weevil. It appears

to be somewhat restricted in its range in southern Europe. Although introduced into Utah in 1911, 1912, and 1913, it was not established in that state. (Chamberlin, 1924*a*, 1924*b*).

This parasite was introduced into California from southern Europe by the United States Department of Agriculture Bureau of Entomology, and the California Agricultural Experiment Station in the summer of 1933.



Fig. 15.—*Anaphoidea luna* Girault, a minute mymarid egg parasite of the alfalfa weevil: adult male; antenna of female above and to the right. This parasite was recently introduced into California. (After Webster, U. S. Department of Agriculture, Bureau of Entomology, 1912.)

Dibrachoides dynastes (Förster), Family Pteromalidae; (Chamberlin, 1924*a*).

Pteromalus dynastes Förster (1841), (Dalla Torre, 1898).

This is a small dull metallic-green and brownish parasite, 3 mm long. It is an external feeder on the prepupae and the pupae of the alfalfa weevil, and, according to Chamberlin (1924*a*), probably the most important parasite on these stages of the weevil in Europe. Three or four eggs are laid on the host and from one to as many adults may emerge from a single host. The prepupal stage of the weevil is preferred to the pupal. It hibernates as an adult. (H. D. Smith, 1930.)

This parasite is recorded in Germany by Förster (1841), in southern Russia by Grossheim (1913) and Kurdjumov (1913), and in France and Italy by Chamberlin (1924*a*, 1924*b*) and H. D. Smith (1930). It was introduced into California during the summer of 1933 by the United States

Department of Agriculture Bureau of Entomology and the California Agricultural Experiment Station.

In Europe a secondary parasite, a eulophid, *Pleurotropis* sp., attacks the pupae of this primary parasite.

This primary parasite was introduced into and artificially colonized in Utah in 1911 (H. D. Smith, 1930) and was found on the lesser clover leaf weevil, *Phytonomus nigrirostris* (Fab.) in Washington by Rockwood (1920) in 1920. Apparently it is of little consequence as yet in this country.

Eutelus sp., Family Pteromalidae.

This undetermined species is listed as a parasite of the alfalfa weevil in Italy by Martelli (1911).

Peridesmia phytonomi Gahan (1923), Family Pteromalidae; (Chamberlin, 1924*b*).

The larvae feed externally upon the eggs of the alfalfa weevil. This parasite is thought to be the most important and promising of the European parasites of the alfalfa weevil. It may be found feeding on egg masses in either green or dry stems of alfalfa. When in the latter they usually are preying on the eggs of the clover leaf weevil. In southern Europe the larvae are found feeding on egg masses in the fields from January to July, according to the locality. The highest parasitism of the weevil by this parasite was noted at Hyères, France, where it ranged from 10 per cent to 30 per cent. Concerning its climatic range Chamberlin (1924*b*) states:

> This parasite occurs in the most southerly point in French Riviera where frost rarely occurs and where the alfalfa grows practically throughout the year and also in Higher Savoy, altitude 2,500 feet, which has short summers and long winters and is one of the highest and coldest sections in France where alfalfa can be grown.

This parasite was introduced into California during the summer of 1933 by the United States Department of Agriculture Bureau of Entomology and the California Agricultural Experiment Station.

Spintherus sp., Family Pteromalidae ("Pteromalid B"); (Chamberlin, 1924*a*, 1924*b*).

An external egg parasite of the alfalfa weevil, this species, according to Chamberlin (1924*b*), is the most dominant egg parasite in the higher and colder regions of France and one of the most promising alfalfa-weevil parasites in Europe. It also occurs in the warmer lowlands of Sicily, showing an adaptation to wide climatic range. Its habits are similar to those of *Peridesmia phytonomi* Gahan.

Another member of this family designated as "Pteromalid A" is an external egg parasite on the alfalfa weevil in southern Europe, according to Webster (1912) and Chamberlin (1924*a*).

Tetrastichus incertus (Ratzeburg), Family Tetrastichidae; (Chamberlin, 1924*b*).

Eulophus incertus Ratzeburg (1844), (Dalla Torre, 1898).

This is an internal parasite of the larvae and prepupae of the alfalfa weevil. Oviposition occurs in the larvae, which turn yellow, pink, and finally reddish brown, and become plump in form. From 6 to 17 larvae of the parasite may occur within each larva of the weevil. It is one of the most promising parasites and exceeded the parasitism of any other alfalfa-weevil parasite in Europe, the effectiveness ranging from 54.6 per cent to 85.8 per cent, with an average of 71.2 per cent, in Italy. It is known to occur in Italy, France, Switzerland (Chamberlin, 1925*a*), and Germany (Dalla Torre, 1898).

A secondary, *Eupelmus atropurpureus* Dalman (1820), was reared from a single prepupa of the alfalfa weevil. (Chamberlin, 1925*a*.)

Tetrastichus sp., Family Tetrastichidae.

This undetermined species is recorded as an internal parasite of the larvae of the alfalfa weevil in southern Russia by Grossheim (1913). It may prove to be *T. incertus* (Ratz.).

ENTOMOPHTHORALES, OR FUNGUS PARASITES

Among the plants are certain fungi, which because they are mostly parasitic on insects, are known as entomogenous fungi. They cause epizoötics of larvae and adults of insects and at times are most effective in destroying great numbers of noxious species. In arid and semiarid regions, they appear to be abundant and beneficial only in wet seasons in spring or early summer. Wherever moisture is present, as along streams and irrigation ditches, these fungi may remain effective throughout much of the summer and fall. Infected insects, after death, are usually enveloped in a loose, white cotton-like growth of fungus mycelium, which serves as an indication of the presence of the fungi. Several species have been recorded as attacking the alfalfa weevil, clover leaf weevil, and other insects in Europe and in this country, but they are of little economic importance in reducing the weevil populations in the alfalfa fields.

The recorded species follow:

Entomophthora phytonomi Arthur.—This fungus has been reported as attacking the larvae of the alfalfa weevil in Denmark by Lind, Ros-

trup, and Kølpin Ravn (1917) and the larvae of the alfalfa weevil and the clover leaf weevil in France by Picard (1914*a*). The same species, listed as *Empusa sphaerosperma* Fresen [*Entomophthora sphaerosperma* (Fresen)] (Picard, 1914*b*), is credited with destroying from 38 per cent to 44.5 per cent of the alfalfa weevil in some localities in Utah in August, 1911, by Webster (1912).

Entomophthora (*Tarichium*) *punctata* Garbowski.—This is described as a new fungus, parasitic on the alfalfa weevil in the Poznań Province, Poland, by Garbowski (1927).

Sporotrichum globuliferum Spegazzini.—This species appears to be the most important fungus parasite of adult alfalfa and related weevils in this country. It also attacks the adults of the chinch bug and other insects. This fungus is most abundant in the spring and kills many of the hibernating weevils which are on the ground at that time. Rockwood (1916) first noted it attacking the alfalfa weevil near Salt Lake City, Utah, on March 14, 1914, and found it to be in greatest abundance from April 21 to 29, when a dead weevil was to be found under almost every alfalfa plant. After the cessation of the spring rains the fungus was restricted to fields copiously irrigated, where it persisted generally until July and in one field until September 10. In spite of its occasional abundance it is of little or no importance in the control of the alfalfa weevil.

BIRDS

Many species of birds observed feeding on the alfalfa weevil in North America have been listed by Webster (1912), Beal (1913, 1914), Kalmbach (1914), and McAtee (1921). It is remarkable that so many birds have taken advantage of this new food. Among the more important bird enemies may be listed the following:

Brewer's blackbird, *Euphagus cyanocephalus* (Wagler): among the most effective bird destroyers.

English sparrow, *Passer domesticus domesticus* (Linn.): the most effective of the birds as a destroyer of the alfalfa weevil in the Great Basin.

Killdeer, *Oxyechus vociferus* (Linn.): a very effective destroyer of the weevil.

Valley quail, *Lophortyx californica vallicola* (Ridgway): an effective enemy of the weevil.

Western chipping sparrow, *Spizella passerina arizonae* Coues: the alfalfa weevil forms four-fifths of its food during months of weevil abundance.

Western lark sparrow, *Chondestes grammacus strigatus* Swainson: an important feeder on the weevil in the spring months.

Western meadowlark, *Stunella neglecta* Audubon destroys many adult weevils in early spring.

Western robin, *Tardus migratorius propinquus* Ridgway: an important enemy of the weevil in the spring.

Western savannah sparrow, *Passerculus sandwichensis alaudinus* Bonaparte: one of the most important destroyers of weevils; during May, June, and July the weevil forms from one-half to two-thirds of its diet.

Western vesper sparrow, *Pooecetes gramineus confinis* Baird: one-half of its food in June and July is composed of a weevil diet.

In Turkestan the wagtail, *Motacilla* sp., is recorded by Smirnov (1913) as an important natural enemy of the alfalfa weevil in that region. These birds appear in March and destroy great numbers of the larvae.

Domestic fowls, chickens, and turkeys are also effective predators on the alfalfa weevil.

OTHER VERTEBRATES

Among other vertebrates which have been recorded as feeding on the alfalfa weevil by Webster (1912) and Kalmbach (1914) are:

Rocky Mountain toad, *Bufo lentiginosus woodhousei:* devours considerable numbers of hibernating weevils in the spring and other adults in early summer.

Leopard frog, *Rana pipiens:* devours many weevils adjacent to water in low damp fields and along irrigating ditches.

Salamander, *Ambystoma tigrinum.*

Blue racer, *Zamenis constrictor flaviventris.*

Horned toads, *Phrynosoma* spp.

Garter snake, *Eutaenia* sp.

Shrew, *Sorex* sp.

ARTIFICIAL CONTROL

As is the case with many serious insect pests, the alfalfa weevil, even where thoroughly established and widely spread, reacts very differently in its various habitats and does not require continuous artificial control in any. The limitations involved are explained more fully in those portions of this bulletin dealing with climatic range, destructiveness, and natural control. Suffice it to say here that under certain favorable conditions the insect becomes very abundant and destructive. The only justification for going into so much detail concerning the many factors which favor and limit these sudden and devastating appearances is to familiarize the alfalfa producer with all the facts necessary for him to judge the situation in his particular locality with regard to the possibilities of weevil increase and to be prepared to check it before it assumes serious proportions. Concerning the normal conditions with regard to the alfalfa weevil in the Great Basin, Reeves (1927*b*) has made this rather pointed comment:

The most baffling feature of the alfalfa-weevil problem is that, in climates where slightly abnormal weather may prevent weevil damage for a given year, growers

tend to persuade themselves that they will never again find it necessary to control the pest. The result is that the next attack finds them off their guard and a crop of hay is lost. One year of unpreparedness in such a case is more costly than many years of preparation which prove unnecessary. Since weather conditions are uncontrollable, it is safest to assume that the only insurance against damage by weevils is a spray outfit and a supply of calcium arsenate.

FARM PRACTICES

Good farm practices often lend themselves to the control of insect pests. Healthy vigorous crops often succeed in spite of insect attacks. Alfalfa-weevil control is especially successful when correlated with up-to-date farming methods. It involves a number of unusual practices, but any method that adds to the economic success of a crop should fall within this classification. It should not be overlooked that these agricultural practices, as well as artificial control, should be more or less generally adopted by the whole community to be most effective and to insure the greatest good to each individual. Those practices which have contributed to the reduction of the weevil and protection of the alfalfa crop are summarized as follows:

1. Clean Culture.—In view of the fact that the adult weevils spend the winter in such protected places as dead weeds, straw, and refuse of varied kinds, it is apparent that the elimination of such litter, especially in and around the alfalfa fields, will cause the weevils to leave in search of such favorable places or to perish for the want of them. Therefore, the destruction of weeds along ditch banks, fences, roads, and in the fields, and of trash and litter around buildings during the late summer, fall, and winter, will do much to expose the weevils to the killing effects of winter (Parks, 1913).

2. Cultivation.—According to many investigators, particularly Titus (1909*a*), Parks (1913), Reeves, Miles, *et al.* (1916), Harris and Butt (1921), Wakeland (1924), and Snow (1925), cultivation of the alfalfa fields with a spring-tooth harrow, disk harrow, or similar tool stimulates growth, and while it does not actually kill any great number of weevils, aids materially in hastening growth and increasing yield. Spring cultivation before growth starts is especially recommended as a means of warming up the soil, promoting draining and air circulation in the soil, and establishing "a better protective mulch against rapid evaporation" (Wakeland, 1924). Reeves, Miles, *et al.* (1916) advocate going over the field twice. The cost was estimated at from $0.60 to $1.25 per acre, which is more than justified by the increase in yield, if not in the actual reduction of the insect pest. It is also recommended that after the cultivation the ground be smoothed with an ordinary spike-tooth harrow.

Where weevils continue in great numbers, summer cultivation, after the cutting of the first crop, is also recommended in Idaho by Parks (1913).

3. Dragging and Dust Mulching.—One of the earliest methods for destroying the alfalfa weevil in Utah was the use of a homemade brush or wire drag, which was found most effective when used after cultivation. The brush drag, as the name indicates, was made of brush tightly bound and weighted down so as to tear up and pulverize the surface soil, thereby crushing many of the insects, exposing others to the killing heat of the sun, and smothering many in the dust. A wire drag was made by placing several layers of heavy woven-wire fencing under an ordinary spike-tooth harrow with the teeth laid flat and enough weight to pulverize the soil (Reeves, Miles, *et al.*, 1916).

Wakeland (1924) has summarized the value of brush dragging as follows:

> To some extent, brush dragging has been relied on in controlling alfalfa weevil. It possesses some merit as an emergency means of control under certain conditions but is not to be recommended as a practical, dependable method. Reliance on this method is based on the fact that both larvae and adults are easily killed by dust and dry heat. The usual practice is to cut the first crop early and then work up a thorough dust mulch by use of a brush drag or a spike-tooth harrow under which is fastened brush or woven wire. For success in creating a dust mulch the field must be dry at cutting time and until after the hay is hauled from the field. A farmer cannot regulate this factor and a rain may interfere any year with his control plans. Even though it may be possible to keep the field dry, to do so is not good farm practice. Dust mulch often necessitates remarking a field before it can be irrigated. Points for and against dust mulching are:
>
> 1. Under limited conditions it will control weevil on second and third crops.
> 2. It will not prevent loss on first crop.
> 3. It cannot be relied on every year.
> 4. It is costly and slow, and if done properly interferes seriously with farm work and alfalfa growth, for which reasons it cannot be considered a good farm practice.

Snow (1925) has also called attention to the fact that dragging is not effective in rocky fields or for the first crop. Reeves, Miles, *et al.* (1916) object to it because it must be done at the busiest time of the year.

4. Sweeping.—A horse-driven street sweeper was used experimentally after cutting the alfalfa in Utah in 1911 by Webster (1912), but while it killed many of the larvae and pupae in the stubble, the cost was prohibitive.

5. Burning.—An oil burner, such as is used for burning weeds, was tried after cutting. It killed exposed larvae and pupae, but any that were protected from the direct flames escaped (Webster, 1912). Such burners

have been experimented with in California for destroying the pea aphid on alfalfa and gave promising results but at a prohibitive cost.

6. Irrigating and Silting.—Irrigation may be classed with cultivating (Hagan, 1918) in its effects upon the alfalfa weevil. It stimulates and hastens growth of the plants, but does not drown many of the various stages of the insect, according to Wakeland (1924). Attention should be called to the fact that after cutting great numbers of the weevils are killed by the heat of the sun, and irrigating prior to cutting would have a tendency to cool the soil and thus nullify much of the killing effect of the heat.

Silting, that is, irrigating in the spring with very muddy water to bury the weevils in a deposit of sediment is suggested for certain limited applicable cases by Reeves, Miles, *et al.* (1916).

7. Puddling.—Puddling after irrigation, suggested by Webster (1912) and Reeves, Miles, *et al.* (1916), consists in dragging a leveler, or similar tool, over the flooded alfalfa fields to "mud-up" the weevils. While it is fairly effective, Hagan (1919) believes it to be of doubtful value because of its ill effects upon the physical condition of the soil.

8. Cutting.—There is much that might be said concerning the proper time to cut alfalfa for hay to reduce the numbers of the alfalfa weevil. It is well known that exposure to the hot sun destroys many of the larvae and pupae and timely cutting may be employed for this purpose. Whenever the destructiveness of the weevil is such as to check the growth of the alfalfa, especially that of the first crop and when most of the eggs have been laid, which in Utah is about the middle of May (Harris and Butt, 1921), then the crop should be cut and the hay removed as quickly as possible to allow the hot sun to destroy the larvae in the stubble. Snow (1925) refers to this practice as follows:

> Making two cuttings of the first crop, when the alfalfa is 15 or 18 inches high and again two weeks later, has much the same effect as pasturing or killing the eggs and larvae before they do much damage. One cutting, if properly timed to remove the bulk of the eggs and young larvae, may prove equally effective. If this cutting is too late the weevils may be so numerous in the stubble as to prevent the normal growth of the next crop.

Wakeland (1924) cautions against indiscriminate cutting of alfalfa in Idaho. He states:

> Cutting the first crop before it has been seriously injured is practiced in some communities, and occasionally a grower obtains good results. His assumption is that he hauls the eggs and weevils in and thus gets rid of them in his hay. This is not in accordance with facts, and in practicing such a method, knowingly or unknowingly, he is relying on heat and dryness to kill the weevils exposed after removal of early cut hay. Alfalfa cut before the early-blossom stage does not have

the feed value that it has when cut at that time, and persistent early cutting weakens the stand. In a weevil-infested field early cutting is usually accompanied by all the evils described under "Cultural Abuse" [withholding of and wrong application of irrigation water] and many stands have been destroyed almost completely by this practice in southwestern Idaho during the past four years.

Reeves and Hamlin (1931*a*) have summarized the influence of cutting the crop on the alfalfa weevil as follows:

In regions where weevil damage is customary and serious farmers are compelled to time their cutting by the stage of injury instead of the stage of growth; and even where the damage is less regular, and early cutting less necessary, it is practiced to a considerable degree. The purpose is to save the existing crop, but the practice also indirectly reduces weevil damage the following year, and it is probable that by this means the farmers of infested localities, after contending with the weevil for several years, unwittingly lower the weevil population and give foundation to Doctor E. D. Ball's surmise that weevil injury automatically tended to subside within 4 or 5 years after its first appearance.

* * * * * *

However, before parasitism brings about the death of the larvae, the cutting of the first crop produces drastic ecological changes in the alfalfa field, killing almost impartially both parasitized and unparasitized larvae. Within one week after the cutting time in 1930 the larval population declined 96.6 per cent. Only 2.4 per cent of this reduction is accounted for by larvae developing into the cocoon stage, the remaining 94.2 per cent of the decrease being due to heat and starvation. This kill operates on larvae of all stages and conditions, but 91 per cent of the survivors are mature larvae. Some of these spin cocoons during the second week after cutting and others succumb to the adversities of the stubble field, so that, two weeks after cutting, the larval population has almost disappeared. It is then renewed by the hatching of the eggs laid, after the first cutting, by the few surviving overwintering adults.

A survey of present methods of control employed in Utah indicates that cutting at most opportune times, as indicated above, is the most important single factor in keeping the alfalfa weevil in check.

9. Pasturing.—Pasturing with livestock, if judiciously practiced, is another method of reducing the populations of the weevil in the spring of the year. Animals may be turned into the infested fields for a few days, for three or four weeks, or permanently, but Hagan (1919) calls attention to permanent pasturing as an injurious practice. During the egg-laying period and the appearance of the newly hatched larvae, in April and May, sheep, in particular, are effective in destroying great numbers of the eggs and larvae. Reeves, Miles, *et al.* (1916) have advocated that in some cases fields be divided into small enclosures for concentrating the feeding of livestock and more thorough destruction of the weevil section by section. Attention is called to the danger of bloating and the impractibility of pasturing where the alfalfa is needed for hay.

10. Replanting.—Replanting of alfalfa is advocated as a means of maintaining crop production as well as an aid in offsetting losses due to the attacks of the alfalfa weevil. Parks (1913) reports that old stands are injured most by the pest, and Snow (1925) adds that crop rotation may result in increasing the crop of alfalfa and in reducing the numbers of the weevil. Hagan (1919) advocates replanting every four to eight years, but prefers a change every six years, whereas Harris and Butt (1921) recommend planting every seven or eight years.

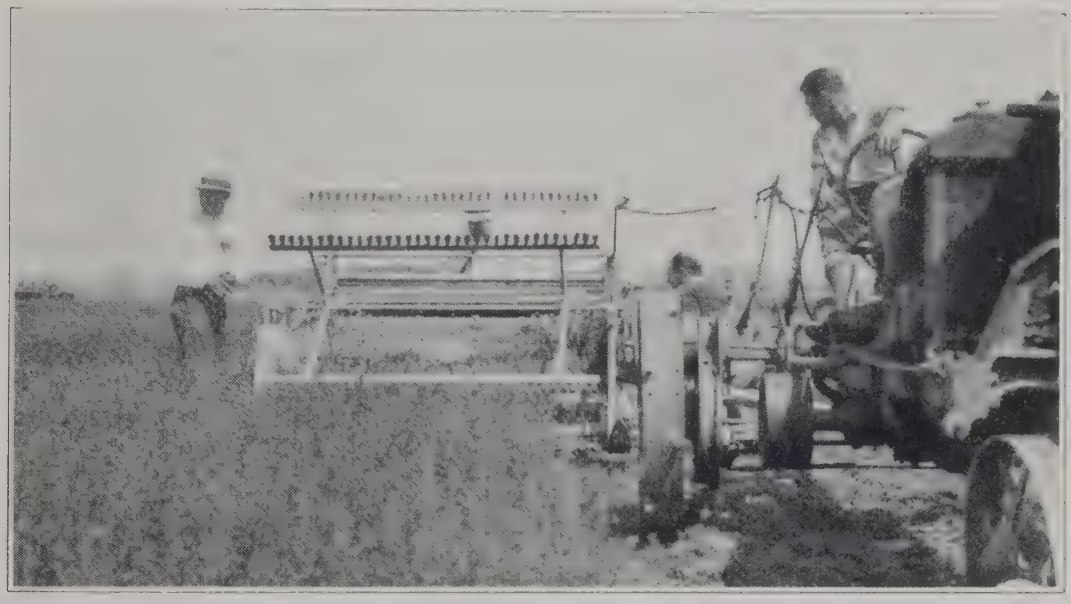


Fig. 16.—A combined mowing and crushing machine in action in an alfalfa field. After passing over the sickle the alfalfa is carried between two powerful rollers which crush the stems and thereby hasten drying in the field.

11. Gathering Machines.—Gathering machines of the ordinary header type, consisting only of the reel and running gear with canvas stretched over the table, at the ends, and across the back to catch the weevils knocked off by the revolving reel, were used by Titus (1910*a*) and a number of farmers in Utah prior to 1910. As many as 145,000,000 specimens of larvae and adults per acre were taken in one field and 166,000 per acre in another. In spite of these large catches the gathering machines did not sufficiently decrease the enormous populations and therefore did not gain favor as a means of economic control.

12. Other Practices.—Among other contrivances which were experimented with in the attempted control of the weevil and which proved ineffective are:

Light traps—the weevils do not fly at night.

Barriers of oil around the fields did not prevent infestations and captured very few adults.

Steaming the stubble after the first crop was removed was unsuccessful.

SPRAYS

Whenever the alfalfa weevil becomes sufficiently abundant to cause serious injury to the alfalfa crop, as has frequently happened in the Great Basin, then the only practical method of handling the situation is the application of poisonous insecticides to effect an immediate check on the ravages of the pest and to save the crop. While the many farm practices previously cited assist in preventing continuous serious attacks, yet they are of little use when once the weevil appears in devasting numbers. It is then that the application of a poison spray or dust will save the alfalfa. While it was generally known to Titus (1910*a*) and others that arsenical sprays would afford an effective means of destroying the larvae of the alfalfa weevil, investigators were cautious in treating growing alfalfa with these materials because of the possible danger to livestock in feeding hay which had been so treated with poisonous compounds. However, during succeeding years trials were made which proved that the small amounts of the insecticides necessary to control the weevil were not seriously toxic to domestic animals, and thus the way was opened to a new solution of the problem of control. These insecticides are applied as sprays and dusts and the relative merits of each type will be discussed separately.

The first satisfactory spray program for the control of the alfalfa weevil appears to have been proposed by Reeves and his associates in 1916 (Reeves, Miles, *et al.*, 1916). Two applications were advocated: one in the spring using 4 pounds of zinc arsenite to every 100 gallons of water and applied at the rate of 50 to 100 gallons per acre; and in places where the weevils reappeared in destructive numbers, a summer application consisting of either 1 pound of paris green to 100 gallons of water or 6 pounds of arsenate of lead paste to 100 gallons of water. All of these combinations were reported satisfactory and paved the way for a great deal of investigational work with arsenicals.

Hagan (1918) called attention to the effectiveness of a spray composed of 5 pounds of paste arsenate of lead to 100 gallons of water but thought it too costly and possibly poisonous to livestock. The next year, however, Hagan (1919) concluded that spraying was as effective and as cheap as cultural methods and recommended arsenate of lead applied at the rate of 2 pounds per acre by means of a sprayer with a 3-nozzle boom attachment to treat a strip 6 feet wide. The application was to be made about 3 weeks before cutting.

In 1920 Reeves and associates (Reeves, Chamberlin, *et al.*, 1920) published complete recommendations for the control of the alfalfa weevil by

spraying. Their findings were based on the results of seven years' experimentation with arsenicals, a summary of which follows:

The best time to spray in the Great Basin (may be different in California) is about 1 or 2 weeks before the first crop of alfalfa is ready for cutting *when the larvae are most numerous.*

Materials and Amounts.—Either arsenate of lead or arsenite of zinc with the addition of a small amount of laundry soap to spread the spray and make it stick to the plants. The formula is as follows:

Arsenate of lead or Arsenite of zinc	powder or paste	2 pounds 4 pounds
Water		100 gallons
Laundry soap		2 pounds

Application.—Use 100 gallons of the spray mixture per acre at from 75 to 150 pounds pressure.

Equipment.—Power sprayer with sufficient engine power, large tank, strainers, pressure gauges, boom attachment, and nozzles. With proper pressure each nozzle will spray a strip 2 feet wide. A good outfit can carry 10 nozzles and thus treat a strip 20 feet wide. The boom should be about 2 feet above the alfalfa. Each nozzle should deliver 0.9 gallon of spray per minute.

A 10-nozzle outfit is capable of treating at least 25 acres a day.

Cost.—In 1920 the cost of spraying amounted to approximately $1.00 an acre.

Effects of Spray.—The effects of the poison spray should begin to appear in about three days when dead weevil larvae may be found, but the full effects of the treatment cannot be expected until the fifth day and after.

In Oregon, Fulton (1921) recommended a spray of 2 pounds of powdered arsenate of lead and 100 gallons of water to which a little soap is added, applied at the rate of 100 gallons or less per acre one or two weeks before the first crop is cut or when the larvae are numerous enough to affect the crop seriously.

In Colorado arsenate of lead and arsenite of zinc, as recommended by Reeves, were suggested by List and Wakeland (1919), but little control work has been necessary in that state.

Calcium Arsenate.—In Nevada in 1925 calcium arsenate was recommended (Snow, 1925) at the rate of from 3 to 4 pounds per 100 gallons of water applied to from 1½ to 2 acres of alfalfa at a pressure of from 150 to 220 pounds. When applied with horse-drawn traction sprayers, from 20 to 30 acres a day were treated at a cost of $0.68 an acre. One

application made during the period from May 26 to June 13 was usually sufficient, but in rare cases a second spray was applied two weeks after the first.

DUSTS

During recent years dusting has practically replaced spraying in the control of the alfalfa weevil. This is in great part due, not to the greater efficacy of dusts, but rather to the ease and rapidity of application, which make them also less expensive. Then too they may often be applied with hand or light traction equipment when heavy spray outfits could not be dragged over the wet fields.

Dusting with a mixture of sulfur and calcium arsenate showed promise in Utah and Idaho and the results obtained by Reeves and Wakeland are given by Newton (1922). Snow (1925) conducted extensive experiments in Nevada with dusts and recommended a traction duster equipped with a thin-iron, hollow, 18-foot boom, 4 inches in diameter at the center, tapering gradually to ¾ of an inch at each end, connected to the blower at the middle with a 4-inch T-shaped tube, and supported by a 4 × 4 inch timber, 19 feet long. In a row, on the underside of the boom, are $\frac{3}{16}$-inch holes, 1½ inches apart, through which the dust is blown out to cover a strip the width of the boom. Applications with such a machine are effective and should be made when the weather is calm. Dew on the alfalfa helps to stick the powder to the plants. In general best results were obtained from a mixture of equal parts of calcium arsenate and dusting sulfur.

Hand dusters and aeroplanes were later used with encouraging results as reported by Howard (1926). Reeves (1927*b*) adds this caution:

> The use of calcium arsenate in the form of dry dust offers many mechanical advantages, such as getting rid of the great weight of water used in spraying. The dust is applied by means of a traction-driven fan or blower or by airplane, and the mechanical problems involved have been satisfactorily solved. The effect upon the crop has been in some cases even better than that of spraying but until greater uniformity of results is obtained it cannot be recommended.

Doten (1928) stated that dusting with calcium arsenate was as effective as spraying in Nevada in 1927. He further called attention to the fact that it was simpler, required less power, and eliminated the heavy hauling of water. Specially constructed horse-drawn geared dusters were the most promising. Schweiss (1932) also showed clearly that in Nevada, dusting with arsenicals was more effective and cheaper than spraying. Sorenson (1932) confirmed the work of Reeves, Wakeland, Snow, and others concerning the effectiveness of a dusting mixture composed of equal parts of calcium arsenate and sulfur for the control of the alfalfa

weevil in Utah. It was applied at the rate of 5 pounds (2½ pounds of calcium arsenate) per acre at a cost of approximately $0.52 an acre. On the second day after application 50 per cent of the larvae were dead, and 90 per cent within a week.

In middle California in those fields where alfalfa has received the best care none of the infestations of the alfalfa weevil have been sufficiently serious to warrant control measures. Rather serious damage has been noted in poorly kept fields. In case artificial control is necessary in the future, experiments will be immediately undertaken to determine the most effective and least expensive method.

EFFECTS OF THE POISON SPRAYS AND DUSTS UPON THE ALFALFA WEEVIL

All investigators of the alfalfa weevil appear to agree that sprays and dusts are specially valuable in killing the larvae and in this type of control work this point must not be overlooked. The larvae begin to die on the second and third day after treatment, but the full effects of the poisons are not apparent for about a week. The effects of the poisons on the adult weevils are not so well known, but Snow (1925) states:

> The adult weevils after feeding for a few days upon the sprayed alfalfa become sick and stop feeding for a few days and then recover and return to the tops of the plants, by which time the effects of the poison have worn off and the plants have put out new growth. This conclusion is supported by laboratory experiments in which adults have been fed sprayed alfalfa and by field observations which have shown that they are sluggish and act sick for a few days after field has been sprayed.

EFFECTS OF POISON INSECTICIDES APPLIED TO ALFALFA ON LIVESTOCK

In all cases where it becomes necessary to apply arsenical dusts and sprays to alfalfa for the control of the alfalfa weevil, the first question that naturally arises in the minds of the grower is, "What effect will such poisons have upon livestock consuming the treated alfalfa?" That this same inquiry was uppermost in the minds of the entomologists is shown by the fact that early in the alfalfa-weevil investigations, poison sprays, which were at once recognized as effective destroyers of the weevils, were not recommended until after extensive feeding experiments with livestock were conducted to test the effects of the spray on the animals. List and Wakeland (1919) were among the first to state that the arsenate of lead and zinc arsenite sprays were not harmful to livestock. Reeves, Chamberlin, *et al.* (1920) followed with the statement:

There have been many inquiries as to the danger of poisoning livestock by feeding sprayed hay, which are all answered by the fact that such hay is shown by analyses and feeding tests to contain too little poison of any kind to injure farm animals. Many of the cattle which are fed upon it probably take in more arsenic with their drinking water than with their hay, and as for the lead content, few of them would under any circumstances live long enough to show the least effect of it.

In Nevada, Snow (1925), discussing poison insecticides applied to growing alfalfa for the control of the alfalfa weevil, states: "Such poison never injures the hay as feed. At cutting time too little poison remains to make the hay dangerous."

Wakeland (1925) concludes: "Chemical and feeding tests indicate that there is no danger of injury to livestock from eating sprayed hay where the recommended quantity per acre is used. Many reports have been circulated to the contrary, but dozens of cases investigated have shown these reports to be without foundation."

A case is also cited by Wakeland (1925) where "A dairy herd was fed freshly cut, sprayed, immature first-crop alfalfa hauled from the field before it was entirely cured. Part of the slipload was rained on and fed wet. The following day a load of wet hay was hauled and the cattle fed on it for two days. The entire herd went off feed, became badly purged and dropped heavily in milk production." An investigation conducted by the State Veterinarian of Idaho showed "severe gastral enteritis due to sudden change of food from very dry, coarse cutting of 1928 hay to immature, uncured, wet hay and aggravated to a very minor degree by calcium arsenate that had been recently applied as a spray." He continues:

Analysis of the hay made by the Station Chemist showed it contained 43 parts of As_2O_3 (metallic arsenic) per million. Thus, a cow eating 30 pounds of hay per day would consume 9.03 grains of metallic arsenic daily. Hay containing twice this amount has been fed by the Idaho Experiment Station with results that were entirely satisfactory. Testimony of Dr. H. C. Gardiner [Reeves, 1925], in the Riverside Dairy Case in the U. S. District Court of Utah, is to the effect that an animal the size of a cow can eat in safety 30 grains of arsenic daily and that the fatal dose is 300 grains.

* * * * * *

The preponderance of evidence is that there is no danger to livestock from eating sprayed hay. . . . In all future recommendations concerning spraying for alfalfa weevil the Experiment Station will take the precaution to advise thorough curing of hay before feeding and to avoid feeding hay while wet or in a soggy moldy condition and will advise against abrupt changes from non-nitrogenous foods to alfalfa. [Wakeland, 1925.]

Reeves (1927*b*) adds the following:

The arsenic content of sprayed hay ranges from less than 1 grain in terms of white arsenic to nearly 29 grains for 30 pounds of hay, and is usually between 5

and 10 grains. The exceptionally large quantity of 29 grains in one day's ration is within the limit of tolerance of horses and cattle [Reeves, 1925]. It is, therefore, entirely safe to feed sprayed hay to livestock, and there need be no case of arsenical poisoning unless white arsenic, sodium arsenite, or some equally virulent poison is substituted, through carelessness or ignorance, for calcium arsenate. It is important, however, for the man who sprays alfalfa with any arsenical compound to know the symptoms of arsenical poisoning, so that he can distinguish between that malady and colic, overeating, and starvation, the two former of which it is popularly but mistakenly supposed to resemble, and the latter of which is actually much like it.

Arsenical poisoning is produced only by a large dose of arsenic which is absorbed from the intestines into the circulation and attacks the liver. In severe arsenical poisoning there occurs an overintoxication resulting in an actual destruction and conversion into microscopic fat of the cells of liver tissue proper within their framework of connective tissue; and the liver loses its ability to eliminate poisons. In case of a dose sufficient to cause poisoning there is always a considerable quantity of arsenic found in the liver; that is, from 10 to 15 times as much as in the other tissues of the body.

Arsenic produces no lesion of the bones, such as rickets; its effect upon the nutrition of the body, when given in medical doses, is of an opposite character. If an animal is anemic and the nutrition is faulty, arsenic is administered and seems to have the power of taking the place of iron in the red blood corpuscles.

Arsenic does not affect the lungs or trachea except as a tonic, and there is no shortness of breath except as a consequence of pain and shock to the nervous system in acute cases or of stiffness in front of the ensiform cartilage in chronic poisoning.

Another important contribution is by Frederick (1930), who reported the results of a rather extensive feeding experiment as follows: "Alfalfa dusted with calcium arsenate, applied at the rate of 2 pounds to the acre and subsequently cured for hay was fed to livestock throughout a feeding season of from 4 to 6 months without injury to cattle, sheep, and horses."

A recent case of arsenical poisoning to livestock in Germany, in connection with the control of the alfalfa weevil, is cited by Krüger (1933): "Cases of poisoning of pastured cattle by arsenical insecticides have occurred in Germany. In an instance here recorded 3 cows were killed in mid-September by feeding on bird's foot trefoil (*Lotus corniculatus*) that had been dusted on June 18 with an arsenical preparation against *Phytonomus variabilis* (Hbst.). The seed crop had been harvested in August."

In this case no data are given concerning the amount and concentration of poison dust applied.

SUMMARY

The alfalfa weevil, *Phytonomus variabilis* (Herbst), is an Old World insect which occurs more or less coextensively with alfalfa culture throughout Europe, northern Africa, and Asia. It was introduced into the Great Basin of the United States at the beginning of the Twentieth Century and was first noted as a pest of alfalfa in Utah in 1904.

Since its initial introduction into Utah the weevil has spread into the states of Wyoming, Colorado, Idaho, Nevada, Oregon, and California.

In California the insect first appeared east of the Sierra Nevada in Sierra County in 1923. Gradually its distribution extended into Plumas, Lassen, Alpine, and Mono counties. By unknown agencies it was carried into the middle part of the state, being discovered in San Joaquin County in 1932. It now also occurs in Alameda, Contra Costa, Merced, Santa Clara, and Stanislaus counties.

The adult weevils are about $\frac{3}{16}$ inch long and of a gray-brown color. They hibernate in the fields during the winter and the females deposit their minute, shining, oval, yellowish-orange eggs in the stems of the alfalfa plants. The larvae are legless, pale-green worms with white dorsal stripe, and $\frac{1}{4}$ inch in length when full grown. They feed on the leaves and stems of the host plants and spin globular, lace-like cocoons at the bases of the plants in which transformation to the adult or weevil stage occurs.

The climatic conditions of California more nearly simulate those of the Mediterranean region than those of the Great Basin. However, the summer temperatures in the interior valleys of California are much higher than in southern Europe. While there is much more similarity in amount of rainfall in the two regions, California has much dryer summers and this condition coupled with the higher temperatures may have a marked effect on reducing the destructiveness of the weevil in the warmer interior valleys and the semiarid alfalfa districts of the southern part of the state.

The most important food plant of the alfalfa weevil is alfalfa. Certain other members of the genus *Medicago,* including bur clover and several of the genus *Melilotus,* particularly the yellow sweet clover or melilot, are of lesser importance, and a few of the true clovers and vetches are suitable hosts under certain conditions. Of the wild plants in California bur clover and yellow melilot are the most important in maintaining the insect outside of alfalfa fields.

In parts of Asia, Europe, and the Great Basin in the United States severe damage to alfalfa has frequently occurred. In the Great Basin the

most serious injury is done to the first crop. In middle California the only damage of importance has occurred in alfalfa fields that were poorly cared for or completely neglected.

The alfalfa weevil spreads naturally by crawling and by flight, but it may also be carried by wind and by water in irrigating ditches and canals. Artificially it may be transported long distances in hay, railroad cars, automobiles, and similar agencies of commerce.

There are many natural enemies which prey upon the alfalfa weevil. Birds are already a factor of considerable importance wherever the insect has become established over a period of time. Among the insect enemies the most important are the tiny hymenopterous parasites which attack the eggs, larvae, and pupae of the pest. Several of these parasites have recently been introduced into California from the Great Basin and from southern Europe.

Many methods for artificially controlling the alfalfa weevil are employed in the Great Basin of the United States. Among the most important farm practices are cultivating or disking the fields, pasturing, and the proper timing of the cuttings. The last is by far the most valuable method for reducing weevil populations and is the only one now used in many districts. The application of poisons as sprays and dusts has also proved effective. A spray composed of 2 pounds of powdered arsenate of lead or arsenite of zinc, 2 pounds of laundry soap, and 100 gallons of water, has been used with great success; the quantities given are sufficient for 1 acre. A dust prepared by mixing together equal parts of powdered calcium arsenate and dusting sulfur and applied at the rate of 5 pounds per acre has been used successfully in Nevada and elsewhere.

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THE EFFECT OF PRUNING IN THE TRAINING OF YOUNG OLIVE TREES

H. E. JACOB

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THE EFFECT OF PRUNING IN THE TRAINING OF YOUNG OLIVE TREES[1]

H. E. JACOB[2]

The investigation reported in this paper constitutes a continuation and an expansion of the investigation reported by Bioletti[3] in Bulletin 348. The results of the former investigation show a very decided depressing effect on young olive trees resulting apparently from both very heavy and moderately heavy pruning. Trees which had received four successive severe winter prunings made only one-tenth as much average growth as was made by the unpruned trees. Those which had received two light summer prunings and two heavy winter prunings made only one-fourth the average growth of the unpruned trees. Furthermore the unpruned trees were the first to come into bearing and their form was equal to or better than that of the pruned trees. These results suggested the idea that at least the Mission and probably all varieties of olive trees would develop faster, bear earlier, and possibly attain a better form if left unpruned, or practically so, until they reached bearing age.

Certain difficulties were encountered in carrying out the former investigation. In one part of the plot the trees did not receive sufficient water owing to a shortage of irrigation water at the time it was needed. Here the depressing effect of severe pruning was less evident probably because the unpruned trees sooner felt the limiting effect of restriction in water supply. In the part receiving sufficient water, the effect of competition between the pruned and unpruned was evident after the fourth season. The unpruned trees developed most rapidly, monopolized more than their share of soil, and shaded the smaller pruned trees during parts of each day. Consequently the pruned trees suffered not only from the depressing effect of the pruning but from competition with their vigorous rivals—the unpruned trees—for water, light, and soil nutrients. It seemed advisable therefore to repeat the experiment in a modified form and also to extend the work to varieties other than the Mission, which alone was used in the original experiment.

[1] Received for publication August 11, 1933.

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[3] Bioletti, F. T. Pruning young olive trees. California Agr. Exp. Sta. Bul. 348: 87–110. Figs. 1–8. 1922.

A new experimental plot was planted in 1924. The trees of this plot have reached bearing age and the phase of the investigation dealing with the pruning of young trees has been completed. The plan of the experiment and the results obtained are given in the following pages.



Fig. 1.—Mission tree 5 years old having had no pruning. Illustrates system *A* before pruning in 1929.

VARIETIES USED

Mission, Manzanillo, Sevillano, and Ascolano—the four varieties of olives of most importance in California—were used. The Mission tree is of upright growth and very vigorous (fig. 1). The Manzanillo is drooping and less vigorous (fig. 11). The Sevillano and Ascolano are nearly as vigorous as the Mission and intermediate between the Mission and Manzanillo in habit of growth (fig. 4).

PRUNING SYSTEMS USED

Variations in pruning were confined to winter pruning. Summer pruning was limited to the removal of shoots from the rootstocks and of water-sprouts on the trunks. No summer pruning was done in the tops of any of the trees. Five systems of winter pruning were employed.



Fig. 2.—Mission tree 5 years old shaped by a single pruning. The tree has been opened up by removing several large branches and lightly thinning out the laterals on the remaining branches. Illustrates system *A* after pruning in 1929. Same tree as in figure 1.

System A: Under this system little or no pruning of the branches was practiced until the trees reached bearing age. During the first five years an occasional ill-placed branch was removed where it seemed evident that its removal later would damage other branches needed to form the

permanent framework of the tree. Suckers or water-sprouts at or below the surface of the soil were removed several times each year during the first three years. No thinning of twigs or small branches was done on any part of the tree during the first four years.



Fig. 3.—Mission tree 5 years old which has been shaped by light annual pruning. Illustrates system *C* after pruning in 1929.

A light crop was borne the fifth season. The following winter the trees were opened up by removing all of the main branches except four, five, or six scaffold branches on each tree. These reserved branches were selected so as to form as nearly as possible a hollow inverted cone with sides rising at an angle of about 60 degrees from the horizontal. After the removal of superfluous large branches, the lower half of the tree was thinned out by the removal of twigs or by cutting back to laterals as much as appeared necessary to prevent overbearing. No topping of the main branches was done. (See figs. 1 and 2, 4 and 5, 11 and 12.)

During the sixth and seventh winters the pruning consisted in the removal of water-sprouts and light thinning of dense portions of the trees.

System B: This system is identical with system *A* except that the very dense skirt of small branches on the lower part of the tree was thinned out the third winter.



Fig. 4.—Ascolano tree 5 years old having had no pruning. Illustrates system *A* before pruning in 1929.

System C: This may be designated as light annual pruning. At the first or second winter pruning, from three to five branches were selected for scaffold branches from which the framework of the tree was developed (fig. 3). These were selected so as to be well distributed around the trunk and with their respective origins from the trunk as far apart vertically as the development of the individual tree would permit.

Each year branches not desired for the scaffold were repressed by shortening, or were removed entirely where their presence threatened to interfere seriously with the development of the desired form. Surplus

branches were allowed to remain wherever this was possible without seriously affecting the development of the scaffold branches. To obtain an even development of the permanent branches, the few that grew much more vigorously than the others were restrained by cutting back to a lateral extending in the desired direction.



Fig. 5.—The same Ascolano tree as shown in figure 4, after pruning. Illustrates system *A* after pruning in 1929.

The skirt of small branches on the lower part of the tree was thinned out lightly at each annual pruning. The growth on the scaffold branches of the Manzanillo was thinned out annually in order to lighten the weight of crop and foliage and reduce the tendency to droop. This was done also with Sevillano and Ascolano in cases where they showed the same tendency. The thinning was done by removing laterals or portions of laterals. No thinning was done on the scaffold branches of the Mission until the fifth winter.

At the fifth winter pruning, most of the surplus branches which had

been held back by annual pruning were removed entirely and the growth on the scaffold branches, where very dense, was thinned out to prevent overbearing the following season. This thinning out of laterals on the scaffold branches was fairly heavy with the Manzanillo, Sevillano, and Ascolano, and very light with the Mission (figs. 3 and 6).



Fig. 6.—Ascolano tree 5 years old which has been shaped by light annual pruning. Illustrates system *C* after pruning in 1929.

System D: The pruning under this system was identical with that of system *C*, but in addition to pruning, mechanical means were employed where needed to hold the scaffold branches in position for one or two seasons. On the Mission a double-pointed piece of hardwood was inserted between crowding scaffold branches to hold them apart for one season, after which they maintained their relative positions without the spreader. Not more than three spreaders were used on any tree and most of the trees did not require any.

With the Manzanillo trees under this system the scaffold branches

were supported during the second and third seasons by bands of burlap about 3 inches wide passed around the tree and nailed to a stake about 4½ feet high (figs. 7 and 13). Where individual scaffold branches showed a strong tendency to droop and could not be supported by this means, owing to the limited height of the stake, they were supported by



Fig. 7.—Manzanillo tree 2 years old supported by a band of cloth passed around the tree and the ends nailed to a stake.

tying to one or two opposing branches by means of tarred grape twine. The twine was fastened to screw-eyes inserted in the respective branches. Many branches were supported in this manner during the third season and a few during the fourth season. No tying was done after the fourth season.

The scaffold branches of the Sevillano and Ascolano grew very nearly in the desired position and required practically no artificial support. An occasional branch was kept in place with tarred grape twine and screw-eyes as was done with the Manzanillo.

System E: The trees under this system were heavily pruned annually. At the first winter pruning three or four branches were selected for scaffold branches and all others removed. These selected branches were cut back to about 6 inches and all of their lateral branches removed. At the second and subsequent prunings, all new branches and twigs starting



Fig. 8.—Ascolano tree 5 years old which has been severely pruned annually. Left, before pruning in 1929. Right, the same tree after pruning in 1929.

from the trunk were removed and the growth on the scaffold branches was heavily thinned. Any scaffold branch not growing in the desired direction was cut back to a lateral extending in the proper direction and the other branches were cut back to a similar height. This type of pruning was continued for five successive seasons. It was intended to be as nearly as possible a duplication of the heavy annual pruning practiced in the previous experiment and reported in Bulletin 348, but on a different variety—Ascolano (fig. 8). Mission was used in the former investigation.

SPACING AND ARRANGEMENT OF THE TREES

An orchard of 168 trees was planted in March, 1924, at the University Farm, Davis, in accordance with the planting plan shown in figure 9.

A permanent orchard of trees spaced 30 x 30 feet was desired for future experiments in pruning bearing trees. In order, however, to pro-

ORCHARD PLAN

N
W E
S

Pruning system	Row	Trees in the row 1	2	3	4	5	6	7	8	9	10	11	12	
		Irrig. line												
A	1	.	.	.	.	.	.	.	.					
B	2	.	0	.	0	.	0	.	0	0	0	0	0	Mission
C	3	.	.	.	.	.	.	.	.					
D	4	.	0	.	0	.	0	.	0	0	0	0	0	
A	5	.	.	.	.	.	.	.	.					
B	6	.	0	.	0	.	0	.	0	0	0	0	0	Sevillano
C	7	.	.	.	.	.	.	.	.					
D	8	.	0	.	0	.	0	.	0	0	0	0	0	
A	9	.	.	.	.	.	.	.	.					
B	10	.	0	.	0	.	0	.	0	0	0	0	0	
E	11	.	.	.	.	.	.	.	.					Ascolano
D	12	.	0	.	0	.	0	.	0	0	0	0	0	
C	13	.	.	.	.	.	.	.	.					
B	14	.	0	.	0	.	0	.	0	0	0	0	0	
A	15	.	.	.	.	.	.	.	.					
D	16	.	0	.	0	.	0	.	0	0	0	0	0	Manzanillo
C	17	.	.	.	.	.	.	.	.					

0 - permanent trees
. - temporary trees

Fig. 9.—Planting plan of the pruning plot.

vide a larger number of young trees upon which to try the various systems of pruning young trees, half of the area of the plot was planted 15 x 15 feet and the other half 30 x 30 feet; three-fourths of the close-planted trees were to be removed when they reached bearing age. This spacing was sufficient to allow uniform development of the individual trees up to bearing age, and all the trees of the orchard were therefore used in the tests. The plot was bordered on all four sides by avenues or roadways 20 feet or more in width.

PLANTING

The Mission trees were grown from cuttings in a nursery at Davis. At the time of planting in the orchard they were several years old and the circumference of the trunks (measured 4 inches above the ground level) varied from 8.4 inches for the largest to 5.5 inches for the smallest (see table 1).

The Manzanillo, Sevillano, and Ascolano trees were purchased from commercial nurseries. All were grafted on Redding[4] stock and their exact age was unknown. At 4 inches above the ground level the Manzanillo trees varied in trunk circumference from 1.9 to 1.1 inches; the Sevillano from 1.7 to 1.1 inches; and the Ascolano from 2.1 to 1.1 inches.

Pruning before planting consisted, in the case of the Mission, in removing all except two or three of the largest branches—removing all laterals and foliage from the retained branches, and shortening them to about 4 inches. The trunk was cut back to not over 30 inches from the ground level. All branches and leaves were removed from the trunks of the Manzanillo, Sevillano, and Ascolano trees, and the trunks were cut back to within 24 inches of the ground level.

The trees were graded before planting according to circumference of trunk, the measurements being taken at the ground level of the nursery row.

In planting, the trees were arranged according to size in order to avoid competition between small and large trees. For example in the case of the Mission, beginning with the largest tree and progressively using trees of smaller size, the order of planting was as follows: Row 1, tree 1; row 2, tree 1; row 3, tree 1; row 4, tree 1; row 4, tree 2; row 3, tree 2; row 2, tree 2; row 1, tree 2; row 1, tree 3, etc. After planting, the trees were whitewashed and were given a light irrigation.

For permanent record, circumference measurements were made after planting, at a height of approximately 4 inches above the soil level (table 1).

CULTURAL CONDITIONS

The soil of the plot belongs to the Yolo loam series and, to a depth of 4 feet, is without marked variations in texture over the area of the plot. Before planting, the land had been subsoiled 18 inches deep at intervals of 3 feet and fallowed for one season. It had been in annual crops for some years and was well leveled for irrigation.

[4] A strong-growing variety often misnamed Picholine.

TABLE 1

CIRCUMFERENCE OF TRUNK MEASUREMENTS TAKEN IMMEDIATELY AFTER PLANTING

(Measurements given in inches, 4 inches above the ground level)

Variety	Row	Pruning system	Tree number in row											
			1	2	3	4	5	6	7	8	9	10	11	12
Mission	1	*A*	8.4	7.0	7.1	6.7	6.9	6.8	6.4	6.1	.....	.....	.....	.....
	2	*B*	7.9	7.5	7.0	6.9	6.9	6.5	6.3	6.0	6.0	6.0	6.0	5.5
	3	*C*	7.6	7.2	7.1	6.9	6.5	6.9	6.4	6.3	.....	.....	.....	.....
	4	*D*	7.4	7.2	7.0	6.8	6.2	6.3	6.3	6.1	6.2	5.7	6.0	5.9
Sevillano	5	*A*	1.7	1.5	1.5	1.3	1.1	1.4	1.3	*1.3*	.....	.....	.....	.....
	6	*B*	1.6	*1.4**	1.5	1.4	*1.4*	1.3	*1.3*	1.3	*1.3*	1.2	1.3	1.1
	7	*C*	1.6	1.5	1.4	1.4	1.4	*1.3*	1.3	*1.1*	.....	.....	.....	.....
	8	*D*	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.1	1.2	1.3	1.1
Ascolano	9	*A*	2.1	1.6	1.5	1.5	1.3	1.3	1.5	1.3	.....	.....	.....	.....
	10	*B*	2.0	1.7	1.6	1.4	*1.5*	1.3	*1.4*	1.3	1.3	1.3	1.3	1.1
	11	*E*	1.9	1.8	*1.6*	1.5	1.5	1.4	1.4	1.3	.....	.....	.....	.....
	12	*D*	1.9	1.6	1.5	1.5	1.5	1.5	*1.4*	*1.3*	1.3	*1.3*	1.3	1.2
	13	*C*	1.9	1.9	*1.5*	1.5	1.5	1.4	1.1	1.3	.....	.....	.....	.....
Manzanillo	14	*B*	1.9	1.6	1.4	1.2	1.3	1.2	1.3	1.2	1.2	1.2	*1.2*	1.2
	15	*A*	1.9	*1.6*	1.5	1.3	1.3	1.2	1.3	1.3	.....	.....	.....	.....
	16	*D*	1.6	1.5	1.4	*1.3*	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.1
	17	*C*	1.5	1.5	1.5	*1.4*	*1.4*	1.3	1.4	1.3	.....	.....	.....	.....

* Trees indicated by italics died the first year and were replaced the second year.

The planting, subsequent cultivation, and irrigation were carried out uniformly with all plots. No defect in cultural care was noted except that in October, 1931, the fruit of several of the close-planted trees shriveled owing to insufficient soil moisture.

At the end of the first growing season several trees were dead and a few more had grown poorly. All dead and weak trees were replaced in the spring of 1925 with good trees of similar size and of the same variety. The number of replaced trees was: Mission, 0; Sevillano, 7; Ascolano, 7; Manzanillo, 5. Their position in the plot is shown by italics in table 1.

DATA COLLECTED

Annual measurements and records were made for each tree, showing:

1. Circumference of the trunk, measured by means of a steel tape passed around the trunk at a height of approximately 4 inches from the ground level. The trunk circumferences were then converted to trunk cross-section areas (table 4 and fig. 10).
2. Weights of prunings (table 2).
3. Estimated fraction (percentage) of the total foliage removed by pruning during each of the first three years (table 3).
4. Height of the tree—the average height of an imaginary line drawn across the two highest points of the tree (table 5).
5. Spread of the tree—the greatest distance in an east and west direction, between imaginary lines forming opposite sides of the general contour of the individual tree (table 5).
6. Weights of crops (table 6).
7. Character of the crop as to graded sizes (table 6).

DISCUSSION OF THE DATA

The measurements of tree and crop indicate the specific influence of pruning and the relative merits of the several systems of training when applied to the four varieties. The results are summarized in tables 1 to 6.

Weights of Prunings.—The individual weights of the prunings of each tree have been averaged for each row and year (table 2). The figures include the prunings from all trees—original plantings and replants. Since the pruning was done in February or March of each year the first winter pruning was in 1925, the second in 1926, and so on. The trees developed slowly and unevenly during the first two years. The pruning during these years was in accordance with the plan except that any trees of the *C* and *D* systems which had made an insufficient growth

for the selection of scaffold branches were left unpruned until the second winter (1926).

There are no consistent differences in the total weight of prunings taken with the systems *A*, *B*, *C*, and *D* during the first 6 years. With system *E* the total weight of prunings exceeded the average for the variety (Ascolano) in the other systems by 53 per cent (table 2).

TABLE 2

AVERAGE WEIGHT PER TREE OF PRUNINGS REMOVED EACH YEAR, IN POUNDS

Variety	Row	Pruning system	1925*	1926	1927	1928	1929	1930	Total of six years
Mission	1	*A*	.....	.....	.....	.....	87.1	9.0	96.1
	2	*B*	.....	.....	29.0	.....	47.7	13.6	90.2
	3	*C*	0.26	1.4	11.4	15.4	12.1	27.7	68.2
	4	*D*	0.24	1.9	15.0	16.5	17.8	30.4	81.8
Sevillano	5	*A*	.....	.....	.....	.....	37.2	14.3	51.5
	6	*B*	.....	.....	7.5	.....	21.8	12.3	40.7
	7	*C*	0.00	1.2	3.1	10.1	16.3	24.2	54.8
	8	*D*	0.02	1.8	2.9	11.2	13.6	20.5	49.9
Ascolano	9	*A*	.....	.....	.....	.....	43.8	16.9	60.7
	10	*B*	.....	.....	9.5	.....	26.4	12.3	47.3
	11	*E*	0.04	3.9	9.2	17.1	29.7	16.5	76.6
	12	*D*	0.02	1.7	2.6	10.6	13.0	16.1	44.0
	13	*C*	0.02	0.8	1.5	10.6	15.6	19.4	47.7
Manzanillo	14	*B*	.....	.....	5.5	.....	9.2	4.0	20.2
	15	*A*	.....	.....	.....	.....	19.6	3.7	23.3
	16	*D*	0.07	0.6	1.1	6.6	11.2	17.4	37.0
	17	*C*	0.07	0.7	1.5	4.8	8.8	11.4	27.1

* The pruning was done in February or March of the year indicated.

The percentage of the foliage removed from each tree by pruning was carefully estimated for the first three prunings. At the fourth and subsequent prunings the trees were so large that such estimates were very difficult to make and they were discontinued. Table 3 gives the average estimated percentage of foliage removed from the trees of each row for each of the first three seasons.

In April, 1931, all of the trees of rows 1 and 3, and trees 1, 3, 5, and 7 of rows 2 and 4 were removed and weighed in order to make direct comparison of the amount of growth made by the annually pruned trees of systems *C* and *D* with that made by the trees of systems *A* and *B* which had not been pruned each year. The trees were first cut off at a convenient height, and weighed. The stumps were then pulled and the roots cut off close to the base of the trunk. The trunks were weighed and their weights added to the respective top weights. No attempt was made to

obtain the weight of the roots. To the weight of each tree was added the total weight of prunings removed from it during the previous years.

The mean weight of the total growth—weight of the tree plus all previous prunings—of the annually pruned trees (systems *C* and *D*) was 454.9 ± 36.8 pounds; while that of the trees not annually pruned (systems *A* and *B*) was 519.1 ± 21.2 pounds. The difference is not

TABLE 3

AVERAGE ESTIMATED PERCENTAGE OF THE FOLIAGE REMOVED BY PRUNING

Variety	Row	Pruning system	1925	1926	1927
Mission	1	*A*	....	....	....
	2	*B*	....	....	34
	3	*C*	7	5	14
	4	*D*	6	7	19
Sevillano	5	*A*	....	....	....
	6	*B*	....	....	22
	7	*C*	0	24	13
	8	*D*	8	34	12
Ascolano	9	*A*	....	....	....
	10	*B*	....	....	28
	11	*E*	34	70	70
	12	*D*	3	35	16
	13	*C*	3	19	6
Manzanillo	14	*B*	....	....	35
	15	*A*	....	....	....
	16	*D*	20	20	12
	17	*C*	25	32	15

significant and it appears that the trees under the two general types of pruning made approximately equal total growth over the period of the experiment (7 years).

Cross-Section Areas of Trunks.—The individual trunk circumference measurements were converted to cross-section areas and have been averaged for each row and each year as shown in table 4. They are summarized graphically in figure 10.

The unpruned trees (system *A*, rows 1, 5, 9, and 15) were difficult to measure because of branches very close to the ground. It is probable that the measurements recorded for these trees are slightly greater than the actual circumferences. The figures indicate that the unpruned trees in rows 1, 5, and 9 of the Mission, Sevillano, and Ascolano varieties, respectively, made appreciably greater growth prior to 1929 than was made by the trees of these varieties under any of the other pruning systems.

After the severe thinning out of the branches of these trees in 1929, the differences decreased and almost disappeared by 1931 (fig. 10).

With the Manzanillo trees the case is reversed. The trees unpruned up to 1929, and those lightly pruned only once prior to 1929 (systems *A* and *B*, rows 15 and 14), made less growth than the annually pruned

TABLE 4

AVERAGE TRUNK CROSS-SECTION AREA OF THE TREES OF EACH ROW BY YEARS, IN SQUARE INCHES*

Variety	Row	Pruning system	1924†	1925	1926	1927	1928	1929	1930	1931
Mission	1	*A*	3.83	3.88	6.68	14.25	27.90	37.98	53.17	Trees removed
	2	*B*	3.46	3.57	5.81	13.72	22.37	33.08	47.66	72.17‡
	3	*C*	3.75	3.77	4.87	11.55	21.10	27.59	40.58	Trees removed
	4	*D*	3.32	3.53	5.53	13.83	24.26	33.68	50.50	78.74
Sevillano	5	*A*	0.16	0.28	2.08	10.23	23.25	32.46	45.01	51.31
	6	*B*	0.14	0.25	1.81	7.44	18.12	22.41	38.47	49.89
	7	*C*	0.16	0.26	1.58	6.40	16.62	23.45	36.52	48.65
	8	*D*	0.14	0.26	1.46	5.66	13.98	23.00	34.04	46.73
Ascolano	9	*A*	0.19	0.31	1.83	7.11	18.85	26.57	35.73	50.90
	10	*B*	0.17	0.31	1.55	5.21	12.40	20.82	36.49	49.63
	11	*E*	0.19	0.28	0.88	4.17	9.16	13.30	18.26	24.54
	12	*D*	0.17	0.28	1.49	5.01	12.06	17.64	30.95	42.83
	13	*C*	0.19	0.29	1.41	4.42	11.41	19.65	32.67	43.01
Manzanillo	14	*B*	0.14	0.19	0.78	2.03	4.11	7.36	14.15	20.89
	15	*A*	0.17	0.23	0.67	2.48	3.88	6.98	13.64	20.65
	16	*D*	0.14	0.25	0.74	2.71	6.43	10.82	19.55	28.95
	17	*C*	0.16	0.25	0.73	2.08	5.94	9.90	19.02	24.44

* The measurements were made in April of each year.

† Replants are omitted in averages for the years 1924 to 1928 inclusive but are included in those of 1929, 1930, and 1931.

‡ Trees 1, 3, 5, and 7 were removed from rows 2 and 4 in April, 1931. The figures given for these rows in the 1931 column are the averages of the remaining trees.

trees (systems *C* and *D*, rows 17 and 16). Representing the size by the cross-section area of the trunk and taking *D* as 100 per cent in each year, the mean size of the trees of *A* and *B* for the years 1927 to 1931, inclusive, is respectively 83, 63, 67, 71, and 72 per cent. The cause of this difference is not evident.

The severely pruned Ascolano trees of row 11 made less growth than did the other trees of this variety. This difference in growth increased as the trees became older and in 1931 the average cross-section area of the trunks of the severely pruned trees was only 53 per cent of that of the average of the other Ascolano trees.

Height and Spread of the Trees.—Height and spread measurements

were obtained for each year but only those taken at the end of the seventh year need be summarized. Table 5 shows the average height and spread of the trees of each row in 1931—the end of the seventh year—and also

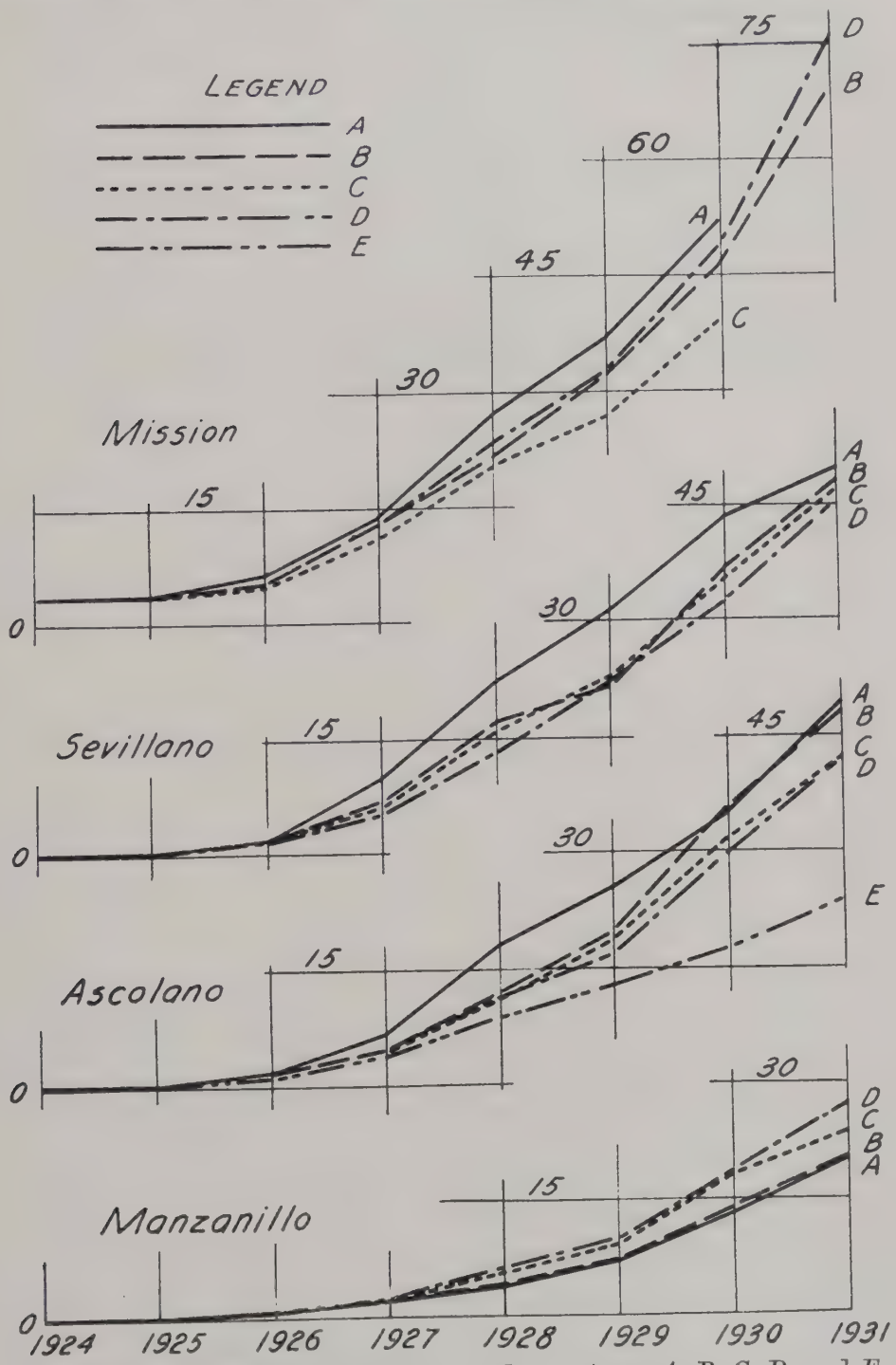


Fig. 10.—Growth of olive trees under systems *A*, *B*, *C*, *D*, and *E* as shown by the cross-section areas of the trunks. The varieties are plotted separately but on the same scale showing average trunk cross-section areas in square inches for each year.

the product of the average spread multiplied by the average height. These figures do not show any appreciable differences in height or spread of Mission, Sevillano, or Ascolano trees pruned according to systems

A, *B*, *C*, or *D*. The severely pruned trees of row 11 (system *E*) are considerably smaller than those of the other four rows of Ascolano. It appears that the Manzanillo trees of rows 16 and 17 under pruning systems *D* and *C* are slightly taller than the trees of rows 14 and 15 which are under pruning systems *B* and *A*, respectively, but they have the same spread.

TABLE 5

HEIGHT AND SPREAD OF THE TREES AT THE END OF SEVEN YEARS
(Averages of the trees of each row)

Variety	Row	Pruning system	Height, feet	Spread, feet	Height × spread, square feet
Mission	1	*A*	.....	Trees removed	.....
	2	*B*	18.7	14.8	275.5
	3	*C*	.....	Trees removed	.....
	4	*D*	19 0	15.7	299 1
Sevillano	5	*A*	14 4	14.1	203 4
	6	*B*	14.1	14.1	199.1
	7	*C*	14 4	13 4	193 7
	8	*D*	14.1	13 8	194 7
Ascolano	9	*A*	15.1	14.4	217.4
	10	*B*	15.4	14 8	227 0
	11	*E*	8.5	8.2	69.9
	12	*D*	14.8	14.1	208.7
	13	*C*	14.4	14.1	203.4
Manzanillo	14	*B*	10.8	11.2	120.5
	15	*A*	9.8	11.8	116.2
	16	*D*	12.5	11.8	147.4
	17	*C*	11.8	11.8	139.9

Crop.—There was no crop in 1927—the fourth season after planting—except a few scattered fruits on unpruned trees. In 1928 the unpruned trees (system *A*) bore a small crop; the lightly pruned trees (systems *B*, *C*, and *D*) a very light crop; and the severely pruned trees (system *E*) none. Spring frost reduced the 1929 crop. In 1930 the first crop of commercial importance was produced. The Sevillano, Ascolano, and Manzanillo varieties were harvested and graded. The Missions were frozen before they matured and were not harvested. Table 6 gives the average weight of crop for the trees of each row for 1928 to 1930, and the percentage of large-sized fruits in the 1928 and 1930 crops.

In 1928 the unpruned trees outyielded all others. This crop, however, was too small for the differences to be of much practical value. The 1929 and subsequent crops were not greatly different on the trees of any single variety under pruning systems *A*, *B*, *C*, and *D*. The severely

pruned Ascolano trees of row 11 did not produce a crop of commercial importance within the 7-year period of the experiment.

Influence of the Variety.—Figure 10 shows the growth of the trees during the 7 years (except for two rows of Missions which were removed).

TABLE 6

SUMMARY OF CROP RECORDS

(Averages of the trees of each row for each year expressed in pounds)

Variety	Row	Pruning system	1928		1929	1930		Total of 3 crops, average weight per tree
			Average weight per tree	Per cent* large size	Average weight per tree†	Average weight‡ per tree	Per cent large size	
Mission	1	*A*	29.9	67	33.2	.....	....	.....
	2	*B*	14.7	53	29.0	.....	....	.....
	3	*C*	16.9	53	39.2	.....	....	.....
	4	*D*	17.8	51	46.4	.....	....	.....
Sevillano	5	*A*	15.8	76	19.4	61.2	72	96.4
	6	*B*	4.6	88	11.0	57.4	81	73.0
	7	*C*	3.3	80	8.8	53.0	72	65.1
	8	*D*	3.5	91	14.7	55.0	73	73.3
Ascolano	9	*A*	24.0	65	31.0	74.1	73	129.1
	10	*B*	11.9	62	22.7	72.2	74	106.7
	11	*E*	0.0	....	0.0	8.6	77	8.6
	12	*D*	3.7	71	18.0	72.2	75	93.9
	13	*C*	7.5	60	11.7	75.9	73	97.2
Manzanillo	14	*B*	4.4	88	0.6	19.4	91	24.4
	15	*A*	5.9	86	2.6	22.9	86	31.5
	16	*D*	2.9	90	1.8	33.0	93	37.6
	17	*C*	2.6	94	2.0	21.1	95	25.7

* Per cent large size indicates the percentage, by weight, of the fruit which in short diameter exceeded the measurements as follows: for Mission 10/16 inch; for Sevillano 25/32 inch; for Ascolano 25/32 inch; for Manzanillo 11/16 inch.

† The 1929 crop was not graded.

‡ The 1930 crop of Mission was frozen before maturity and was not harvested.

By 1930 the mean growth of the Manzanillo under all systems was only about one-half that of the Sevillano and Ascolano, while the growth of the Mission was about a third greater than these. The Manzanillo is naturally a slow grower but the more rapid growth of the Mission is due only in part to any inherent quality it may have in this respect. The Mission trees were older and larger when planted than were the other varieties after two years growth in the field. The greater development of the Mission trees is therefore apparently due to the larger size of the trees when planted. They were of about the same size in 1929 as the Sevillanos and Ascolanos were in 1930; and in 1930 the Missions were as large as the Sevillanos and Ascolanos were in 1931.

Influence of the System of Pruning.—The retardation of growth caused by heavy pruning is clearly shown by the trees under system *E* when these are compared with the other Ascolano trees under systems *A*, *B*, *C*, and *D*. When planted, the trees were of similar size (see table 1). In 1927 the cross-section area of the trunks of the severely pruned trees



Fig. 11.—Manzanillo tree 5 years old having had no pruning. Illustrates system *A* before pruning in 1929.

was only 77 per cent of the average of the unpruned and lightly pruned trees of the same variety, and fell to 67 per cent, 63 per cent, 54 per cent, and 53 per cent during the succeeding years. They bore no crop until 1930 and then only 8.6 pounds per tree which was 11.7 per cent of the mean crop of the other Ascolano trees of that year. The Mission, Sevillano, and Ascolano trees under system *A* grew more rapidly than those under systems *B*, *C*, and *D* prior to the opening up and thinning-out process begun in 1929 and completed in 1930. Following this heavy pruning the rate of growth of the trees under system *A* decreased relatively to that of the trees under systems *B*, *C*, and *D*, and in 1931 there were no considerable differences in size. The rate of growth of the Mis-

sion, Sevillano, and Ascolano trees under systems *B*, *C*, and *D* was not greatly different at any time during the investigation (fig. 10 and table 4).

The Manzanillo trees under system *D* grew faster after 1927 than did the trees of this variety under any other system. It is not clear why



Fig. 12.—The same Manzanillo tree as shown in figure 11, after pruning in 1929. Illustrates system *A* after pruning.

these annually pruned trees showed a greater growth than those under system *A* which were unpruned until 1929.[5] The crop on all of the Manzanillo trees prior to 1930 was very light and in that year the trees under system *D* outyielded those under any other system.

All of the trees of the Mission, Sevillano, and Ascolano varieties were well shaped at the end of the pruning experiment. The distribution of the scaffold branches on the trunk was best on the annually pruned trees

[5] A possible explanation of the better growth of the annually pruned trees might be in their changed habit of growth. The unpruned trees were bush-like in character and the branches were long and drooping. The annually pruned trees were more upright in growth. It is well known that bending the branches of woody plants tends to check their growth.

(systems *C* and *D*). The main branches of the Mission trees which were opened up by heavy pruning in 1929 (systems *A* and *B*) were slightly more spreading than those of the annually pruned trees (systems *C* and *D*). (Compare figures 2 and 3.) The Sevillano and Ascolano trees showed little or no advantage in shape of tree of one pruning system over any



Fig. 13.—Manzanillo tree 5 years old shaped by tying and light annual pruning. Thinning the laterals on the main branches has lessened their tendency to droop. Illustrates system *D* after pruning in 1929.

of the others. Figure 4 shows a five-year-old Ascolano tree of system *A* before pruning and figure 5 shows this same tree after pruning in 1929. One of the five-year-old Ascolano trees lightly pruned annually is shown in figure 6. The annually pruned Manzanillo trees (systems *C* and *D*) were slightly taller and more upright than those pruned only once (system *A*) or twice (system *B*) which tended to be bush-like in shape during the first five years in the orchard (fig. 11; this same tree after pruning is shown in figure 12.) This difference was pronounced in 1929

but less striking in 1931. The Manzanillo trees of system *D* which had been supported by tying and internal bracing appeared to be better shaped in 1929 than those of system *C* which had not been tied. Figure 13 shows a Manzanillo tree formed by annual pruning and tying. However, this difference was not apparent in 1931 or later and it appears doubtful that any permanent advantage resulted from the tying or bracing. The trees of the other three varieties showed little or no difference in this respect between systems *C* and *D*.

The shaping of the trees mainly by a single heavy pruning (systems *A* and *B*) resulted in many large pruning wounds on the trunks and scaffold branches of the trees. However, the wounds healed rapidly. The trees lightly pruned annually (systems *C* and *D*) were nearly free from large wounds. Careful examination in April, 1933, failed to disclose any evidence of decay in any of the trees under systems *A*, *B*, *C*, and *D*.

The trunks of the severely pruned trees (system *E*) sunburned on the southwest side. Wood-rot fungi obtained entrance through the sunburned areas and when examined in April, 1933, every trunk of the severely pruned trees was badly decayed. The heartwood of several of the trunks was almost completely destroyed.

SUMMARY AND CONCLUSIONS

The slower development of the severely pruned Ascolano trees (system *E*) as compared with that of Ascolano trees less severely pruned clearly demonstrates the depressing effect of heavy pruning on young olive trees of this variety. The limitation of leaf surface not only diminished photosynthesis but exposed the trunk to the hot rays of the sun with consequent sunburn and fungus decay.

The depressing effect of the single severe pruning necessary to shape and thin the trees that were unpruned until 5 years old (system *A*) was approximately the same as the depressing effect of five light annual prunings (system *C*). The total weight of the removals in each of the two cases was also roughly the same for the Mission, Sevillano, and Ascolano varieties. The Manzanillo trees lightly pruned annually, on the contrary, appear to have developed faster than those left unpruned for three or for five years and this despite the fact that the total weight of removals was greater.

The form of the trees at the end of 7 years was not greatly different whether shaped by light annual pruning or by heavy pruning during the fifth year (or fifth and sixth years). Perhaps the Mission trees shaped mainly by a single pruning the fifth year were slightly superior in form

to those shaped by annual pruning. On the other hand annual pruning produced slightly better-shaped Manzanillo trees (7 years old) than were obtained by one or two prunings. No considerable advantageous differences in form attributable to the pruning could be observed among the Ascolano and Sevillano trees.

Many large pruning wounds resulted from shaping the trees mainly by a single pruning (systems *A* and *B*). The wounds healed rapidly, however, and no decay was observed. The trees lightly pruned annually were nearly free from large wounds. Wood-rot fungi entering through sunburned areas caused much decay in the trunks of the severely pruned Ascolano trees.

The trees left unpruned until 5 years old bore heavier crops in the fifth season than did the pruned trees. The crops during the sixth and subsequent years were about the same on the trees of each variety under all systems except severe pruning. The severely pruned trees did not produce a crop of commercial importance during the seven years.

Artificial supports of the types used in the *D* system produced little or no permanent improvement in the form of the Mission, Sevillano, or Ascolano trees. Tying up the branches of the Manzanillo trees by passing a band of burlap cloth around the tree and supplementing this with internal bracing of the main scaffold branches produced a marked improvement in the shape which was apparent for at least five or six years. At seven years of age, however, the difference between the trees which had been tied and those not tied was not great and it appears doubtful that any permanent improvement has accrued from the tying.

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ANNUAL INDEX NUMBERS OF FARM PRICES, CALIFORNIA, 1910-1933[1, 2]

H. J. STOVER[3]

SUMMARY

It is impractical to attempt to include the prices of all farm products produced in California in a farm-price index for the state. A sample, including products which are representative of the various sources of the cash income of the farmers of the state, and which account for a large percentage of this income, can be expected to give results which do not differ significantly from the index that would be obtained by including all products.

The series of index numbers of farm prices in California from 1910 to 1933, presented herein, include the prices of thirty-five farm products, representing between 85 and 90 per cent of the gross cash income of the farmers of the state. The farm products whose prices are included are beef cattle, veal calves, hogs, sheep, lambs, milk, milk fat, butter, eggs, chickens, wool, horses, barley, wheat, rice, oats, corn, hay, alfalfa, cotton, potatoes, beans, sugar beets (since 1916), oranges (since 1912), lemons (since 1912), apples, grapes, peaches, pears, apricots, cherries, raisins, prunes, walnuts, and almonds.

The availability of satisfactory price series was an important factor in the selection of the products included in the California index. One of the main sources of farm-price data in the United States is the monthly series of prices received by producers of farm products, commonly called "farm prices," collected and published by the Division of Crop and Livestock Estimates of the United States Department of Agriculture. Monthly prices for each of twenty-four of the products included in the California farm-price index were obtainable from this source. Monthly prices for several farm products, particularly fruits and truck crops, of major importance in California have not, however, been collected on a comparable basis—largely on account of the relative unim-

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portance of these products in the United States as a whole. In order that the more important of these products might be represented in the index, it was necessary to obtain price series for them from other sources. In so doing the attempt was made to obtain prices which could be considered representative of a season's average price for each of the products.

In using monthly prices in the construction of an annual index, the problem arose concerning the best method of obtaining annual averages of these monthly series. A comparison of the annual index numbers of farm prices in California based on unweighted averages of monthly prices with those based on weighted averages, the weights used being estimated average percentage monthly marketings of each product, indicated that although the weighting process affected greatly the annual averages for some of the individual products the composite index was not seriously altered. In view of the relatively small differences between these series, unweighted averages of monthly prices were used in the construction of the index numbers presented herein.

A second problem encountered in the preparation of monthly price data for use in the construction of annual index numbers was the choice of a dividing line between successive years. Most annual index numbers of prices are for the calendar years. A crop-year basis is somewhat more significant for agricultural products, however, because of the importance of the supply factor in the determination of farm prices. A fair approximation to a crop-year period, which is satisfactory for most crops in California, was obtained by considering July 1 as the dividing line between successive crop years. In the construction of the annual farm-price indexes for California, price series for both the approximate crop years and the calendar years were compiled and index numbers based on each of these series were calculated. The presentation of both indexes makes possible comparisons of farm prices in California with other series of data on either a crop-year or calendar-year basis.

In combining the prices of the thirty-five California farm products in an index number, the method known as the "weighted aggregative" was used. The price of each product was multiplied by a quantity weight corresponding to the estimated annual quantity of that product marketed during the five-year period, 1924–1928, inclusive; the thirty-five values so obtained were totaled, giving the aggregate value of the group; and the index number was obtained by expressing this aggregate value as a percentage of the corresponding aggregate value of the same products in the base period. Since the quantity of each product was held constant, any change in the aggregate value (price times quantity) was due entirely to price changes.

Two five-year periods, each of which is qualified for use as a base for

the California farm-price index, are available. Since each of these periods had its virtues and its shortcomings, an index based on each period is presented so that one may use whichever serves best a particular purpose. The first of these periods, the five pre-war years, 1910–1914, is one of the most, if not the most, generally accepted base period for price index numbers at the present time. It provides the most satisfactory basis which has been found for comparing the general movements in farm prices during the past quarter of a century with movements in other price series. The second period, extending from 1924 through 1928, is useful as a starting point in judging recent short-range changes in the farm prices of individual products.

According to the index numbers based on the prices for the years beginning July 1, farm prices in California were lower in the year beginning July 1, 1932, than in any other year during the period covered by the index. Between 1910 and 1915, prices were comparatively stable. In 1915 they began to rise and rose rapidly until 1919 when they reached a peak at levels more than double the average for July, 1910 to June, 1915. From then until 1923, farm prices in California declined at a rate approximately equal to that of the preceding advance. Between 1923 and 1929, they were again comparatively stable. By 1931, however, they had declined to levels below that of the pre-war base period.

The major movements in the California farm-price index since 1910 have corresponded with the changes in the general level of prices in the United States. According to the all-commodity index of wholesale prices constructed by the Bureau of Labor Statistics of the United States Department of Labor, one of the more generally accepted measures of the general level of prices in the United States, prices, as a whole, were comparatively stable between 1910 and 1915 and again between 1922 and 1929. They more than doubled between 1915 and 1919, fell abruptly in 1920, and reached pre-war levels in 1931. Farm prices in California, it is to be noted, followed this same general course.

A comparison of the California farm-price index with the index of farm prices in the United States reveals the fact that during the early stages of the World War, when prices were rising at a rapid rate, and again in each of the two post-war periods of general price declines, farm prices in California lagged behind farm prices in the United States. These lags in price movements were due, to a large extent, to the fact that whereas the United States index is weighted heavily with the staple products such as wheat, cotton, and hogs, which respond quickly to changing economic conditions, the index for California includes many specialty crops of major importance in the state whose prices respond more slowly.

Series of index numbers of farm prices constructed in recent years for a number of other states exhibit the same general course during the past twenty years as that followed by farm prices in California. Each series depicts, to a varying degree, the stability of prices from 1910 to 1915 and from 1922 to 1929, the rapid price rise from 1915 to 1919, and the subsequent declines in the early 1920's and early 1930's. Differences between state farm-price index numbers were due, primarily, to the type of products included in the indexes. The California index, for example, followed the index of farm prices for New York more closely (because their composition is more nearly the same) than it followed the indexes for Alabama, Iowa, or North Dakota. The index for Alabama is weighted heavily with cotton prices; the index for Iowa is dominated by the movements in hogs and beef-cattle prices; and the index for North Dakota reflects, to a large extent, changes in the prices of grains.

By comparing the price relative for a product with the corresponding index number of prices for a number of products, one has a basis for evaluating the changes in the price of that product in terms of an average change in the prices of several products. For example, when the period extending from July, 1924, through June, 1929, is taken as a base, the farm prices of beef cattle, veal calves, milk, eggs, chickens, lemons, raisins, and walnuts in California were relatively higher in 1931–32 and in 1932–33 than the average of all products included in the California index. Similarly, the farm prices of hogs, lambs, milk fat, wheat, barley, rice, cotton, potatoes, oranges, peaches, pears, and apricots were relatively lower than the average during those years.

DEFINITION OF PRICE INDEX NUMBERS

An index number of prices is a number which serves to express the average percentage change, from one point of time to another, of the prices of a number of items. It is designed to register the group movement of prices as distinct from the movements of the prices of the individual items composing the group.

Percentage changes in the price of a single commodity from one time to another are obtained by dividing the price at one time by the corresponding price at some other time. This ratio between two prices is called the price relative of the commodity in relation to those two particular times. An index number of prices is an average of the price relatives of a number of commodities—an average designed to represent the general trend of the many diverging ratios from which it is calculated.

NEED FOR AN INDEX OF CALIFORNIA FARM PRICES

Before a farm-price index for California was prepared, an index constructed for the United States as a whole was the only measure of the changes in the prices received by producers for agricultural products available for use in analyzing price situations in California. This index was prepared by the Bureau of Agricultural Economics of the United States Department of Agriculture. It includes the prices of thirty commodities, representing more than 90 per cent of the value of products sold by the farmers of the United States. The prices used are monthly prices based on reports from all parts of the country, and the weights assigned to the various products represent the average annual quantities marketed by farmers during the period, 1918–1923.

In several respects, a farm-price index for the United States as a whole is inadequate for any single state. The relative importance of the commodities produced in various states is different, and prices behave somewhat differently, largely according to whether a particular state is a deficit or a surplus-producing area and whether it is far from, or near to, the consuming centers for a particular product. Wheat, corn, cotton, hogs, and beef cattle bulk large in the national farm income, and, hence, their prices are given much weight in the index for the United States. In California, these products account for less than 15 per cent of the cash income of the farmers of the state. On the other hand, the fruits, especially oranges and grapes, provide a large proportion of the agricultural cash income of California, but are relatively unimportant in the United States as a whole and are either not included or are given little weight in the national index of farm prices. In consequence of these contrasting conditions in the United States as a whole and in California, it follows that an index based on prices received by producers in California for agricultural products (due account being taken of their relative importance in the state) is much more representative of the trends of prices in California than is an index of farm prices designed for the entire United States.

THE CONSTRUCTION OF THE INDEX-NUMBER SERIES

GENERAL SOURCES OF PRICE DATA[4]

One of the main sources of farm-price data in the United States is the monthly series of prices received by producers of farm products, commonly called "farm prices," collected and published by the Division of Crop and Livestock Estimates of the United States Department of Agriculture.[5] These prices represent an estimate of the average price of all grades and classes of each commodity sold in the local farm market on or about the fifteenth of each month. The prices at which the products first changed hands when sold by the producer are reported to the United States Department of Agriculture by a large staff of voluntary correspondents scattered throughout the country. Each month, after the reports are received from these correspondents, the Division of Crop and Livestock Estimates issues a tabulation of farm prices for the United States as a whole and for each state.

Monthly prices for each of twenty-four of the commodities[6] included in the California farm-price index are reported currently for this state. These prices, whenever available, were used in the construction of the index numbers of California farm prices..

Annual prices of rice, sugar beets, grapes, peaches, pears, apricots, cherries, raisins, prunes, walnuts, and almonds, were compiled by the author from other available sources of information. Monthly prices for these commodities are not collected by the United States Department of Agriculture.

UNWEIGHTED VERSUS WEIGHTED ANNUAL AVERAGES OF MONTHLY PRICES

In using monthly prices in an annual index number, the problem arises concerning the best method of obtaining annual averages of these monthly series. The simplest practical procedure to follow is to give the price for each month equal weight in the calculated price for the year. This method involves merely the summation of the twelve

[4] A detailed account of the specific sources of the price data used in the construction of the annual index numbers of farm prices in California is given in Appendix A.

[5] A good discussion of the farm-price data collected by the United States Department of Agriculture is given in: Sarle, C. F. Reliability and adequacy of farm-price data. U. S. Dept. Agr. Dept. Bul. 1480:1–65. 1927.

[6] Beef cattle, veal calves, hogs, sheep, lambs, milk, milk fat, butter, eggs, chickens, wool, horses, barley, wheat, oats, corn, hay, alfalfa, cotton, potatoes, beans, oranges, lemons, and apples.

monthly prices and the division of the sum by 12. The ideal method for obtaining annual prices from monthly data would involve the weighting of the price for each month with the quantity of the product sold in that month. This method necessitates current data on the monthly marketings of each product. Unfortunately, these data are not available. The weighting of monthly prices with a fixed weight for each month, based

TABLE 1

PERCENTAGES USED AS WEIGHTS IN CALCULATING ANNUAL WEIGHTED AVERAGES OF MONTHLY FARM PRICES*

Product	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Beef cattle	7	6	7	8	9	10	11	10	9	8	7	8
Hogs	6	7	8	9	8	7	7	9	12	10	10	7
Sheep	9	5	5	5	8	7	11	10	11	11	9	9
Lambs	5	4	9	16	27	9	6	7	2	4	6	5
Milk fat	8	8	10	11	10	9	8	8	7	7	7	7
Butter	8	8	10	11	10	9	8	8	7	7	7	7
Eggs	8	9	12	10	10	9	8	7	6	7	7	7
Chickens	14	14	7	3	3	5	6	4	4	4	14	22
Wool	4	4	5	6	7	15	22	15	7	6	5	4
Barley	5	5	4	3	7	11	14	18	10	10	8	5
Wheat	8	8	8	6	7	8	8	8	11	10	9	9
Oats	7	7	6	6	4	7	10	11	12	12	10	8
Corn	9	8	7	6	8	8	5	10	12	9	9	9
Hay	5	5	5	6	7	12	14	15	11	8	7	5
Alfalfa	6	6	6	7	9	13	12	11	9	8	7	6
Cotton	6	5	4	3	2	1	1	5	17	24	20	12
Potatoes	7	5	3	2	3	12	12	14	14	11	9	8
Beans	11	9	6	4	4	3	3	3	12	19	14	12
Oranges	8	7	11	12	11	9	8	7	6	5	7	9
Lemons	6	5	8	9	15	16	14	8	5	5	4	5
Apples	3	3	3	2	1	1	18	14	19	23	10	3

* The prices of veal calves, milk, and horses were not weighted.

Sources of data:
Estimates made by the author from data on market receipts, shipments from the state, and the like, of the average monthly marketings of each product.

on estimated *average* monthly marketings of each product, is as near as one can generally approach the ideal method for obtaining annual prices.

Annual weighted average prices for each of the twenty-four products included in the California farm-price indexes for which monthly price data are available were calculated, using the monthly weights given in table 1. These monthly weights are very rough approximations of the average percentage monthly marketings of each product, based on available sources of information. Data on market receipts, shipments from the state, and the like were used in making these estimates.

The difference between weighted and unweighted annual averages of monthly prices varies widely among the products. The annual prices of

products for which there is no pronounced seasonal price variation are not greatly affected by the weighting process, even though the quantities of these products marketed monthly may be highly variable. Likewise, weighted average prices do not differ greatly from unweighted averages when the quantities of the product sold each month are approximately equal.

TABLE 2

COMPARISON OF ANNUAL RELATIVES OF APPLE PRICES IN CALIFORNIA, BASED ON UNWEIGHTED AND WEIGHTED AVERAGES OF THE MONTHLY FARM PRICES, CALENDAR YEARS, 1910–1933
(1924–1928 = 100)

Year beginning January 1	Price relatives based on		Difference*	Year beginning January 1	Price relatives based on		Difference*
	Unweighted average of monthly prices	Weighted average of monthly prices			Unweighted average of monthly prices	Weighted average of monthly prices	
1910	66.0	65.3	0.7	1922	112.8	110.9	1.9
1911	59.1	65.3	−6.2	1923	108.0	109.4	−1.4
1912	64.6	64.6	0.0	1924	107.3	109.4	−2.1
1913	64.0	72.9	−8.9	1925	114.9	120.1	−5.2
1914	68.1	61.6	6.5	1926	92.8	81.3	11.5
1915	57.1	57.0	0.1	1927	89.4	101.8	−12.4
1916	64.6	67.6	−3.0	1928	95.6	87.4	8.2
1917	73.6	76.0	−2.4	1929	97.0	110.9	−13.9
1918	86.0	98.8	−12.8	1930	82.5	61.6	20.9
1919	136.2	128.4	7.8	1931	49.5	56.2	−6.7
1920	141.0	133.0	8.0	1932	52.3	49.4	2.9
1921	99.0	111.7	−12.7	1933	38.5	42.6	−4.1

* Excess of unweighted over weighted average.

Sources of data: Calculations by the author based on prices presented in tables 40 and 42.

One of the products included in the California farm-price index for which annual prices calculated from monthly data are affected a great deal by the weighting process is apples. A comparison of the price relatives (1924–1928 = 100) for apples computed from unweighted and weighted monthly prices is presented in tables 2 and 3. In table 2, the price relatives are for the calendar years and in table 3 for the years beginning July 1.

In 1929, the unweighted average of the apple prices for the twelve months, January through December, was 97.0 per cent of the average for the five preceding years. The weighted average was, however, 110.9 per cent of the corresponding five-year average. This large difference is accounted for by the fact that the apple crop produced in 1929 was light, and prices during the months of heavy market movement were higher than the prices received for that portion of the 1928 crop sold after January 1. Apple prices are usually lower in the fall than in the

spring of the year. The importance of this factor as an explanation of the difference in the 1929 price relatives is indicated in table 3.

On the whole, the differences between price relatives for apples based on unweighted and weighted averages of monthly prices are much less when these relatives are computed for years beginning July 1 than when computed for calendar years. The largest differences for years beginning July 1 occurred during the World War when prices underwent changes of an exceptionally violent character.

TABLE 3

COMPARISON OF ANNUAL RELATIVES OF APPLE PRICES IN CALIFORNIA, BASED ON UNWEIGHTED AND WEIGHTED AVERAGES OF THE MONTHLY FARM PRICES, YEARS BEGINNING JULY 1, 1910–1932
(July, 1924 to June, 1929 = 100)

Year beginning July 1	Price relatives based on		Difference*	Year beginning July 1	Price relatives based on		Difference*
	Unweighted average of monthly prices	Weighted average of monthly prices			Unweighted average of monthly prices	Weighted average of monthly prices	
1910	59.2	64.9	−5.7	1922	110.7	109.9	0.8
1911	67.0	67.2	−0.2	1923	108.6	109.2	−0.6
1912	59.9	62.6	−2.7	1924	115.0	111.5	3.5
1913	78.9	77.1	1.8	1925	111.4	118.3	−6.9
1914	57.8	58.0	−0.2	1926	79.0	77.9	1.1
1915	62.8	58.8	4.0	1927	108.6	108.4	0.2
1916	70.5	68.7	1.8	1928	86.0	84.0	2.0
1917	76.9	77.1	−0.2	1929	114.2	116.0	−1.8
1918	128.3	109.2	19.1	1930	45.1	51.1	−6.0
1919	146.0	130.5	15.5	1931	59.9	58.8	1.1
1920	108.6	124.4	−15.8	1932	40.2	45.0	−4.8
1921	119.2	116.8	2.4				

* Excess of unweighted over weighted averages.

Sources of data: Calculations by the author based on prices presented in tables 41 and 43.

The effect of using annual averages of monthly prices weighted with the values given in table 1, upon the index numbers of the prices of twenty-four products, is shown in tables 4 and 5. The maximum difference between the annual index numbers based on weighted monthly prices and those based on unweighted averages of the monthly prices is 1.6, in 1919, for the calendar years, and 2.4, in 1918–19, for the years beginning July 1. In seventeen of the twenty-four calendar years the difference is 0.5 or less; in all but three, less than 1.0. In ten of the twenty-two years beginning July 1, the difference is 0.5 or less; in all but two years, 1.5 or less.

In the final index-number series, which include the prices of thirty-five commodities, the differences between the results obtained by weight-

TABLE 4

COMPARISON OF ANNUAL INDEX NUMBERS OF FARM PRICES IN CALIFORNIA, BASED ON UNWEIGHTED AND WEIGHTED AVERAGES OF THE MONTHLY PRICES OF TWENTY-FOUR PRODUCTS, CALENDAR YEARS, 1910–1933
(1924–1928 = 100)

Year beginning January 1	Index numbers based on		Difference*	Year beginning January 1	Index numbers based on		Difference*
	Unweighted average of monthly prices	Weighted average of monthly prices			Unweighted average of monthly prices	Weighted average of monthly prices	
1910	73.7	73.7	0.0	1922	94.3	95 2	−0.9
1911	71.5	71.8	−0.3	1923	90.7	92.1	−1.4
1912	70.9	71.4	−0.5	1924	89.7	89.4	0.3
1913	81.4	82.1	−0.7	1925	111.6	112.1	−0.5
1914	68.2	67.9	0.3	1926	93.0	92.5	0.5
1915	66.4	66.3	0.1	1927	97.5	97.5	0.0
1916	77.7	77.4	0.3	1928	108.3	108.5	−0.2
1917	99.0	99.3	−0.3	1929	97.3	96.9	0.4
1918	127.4	127.2	0.2	1930	99.1	98.2	0.9
1919	119.8	121.4	−1.6	1931	60.3	60.5	−0.2
1920	130.0	130.9	−0.9	1932	50.2	48.8	1.4
1921	84.0	84.2	−0.2	1933	46.9	47.3	−0 4

* Excess of unweighted over weighted averages.

Sources of data: Calculations by the author based on data presented in tables 7, 40, and 42.

TABLE 5

COMPARISON OF ANNUAL INDEX NUMBERS OF FARM PRICES IN CALIFORNIA, BASED ON UNWEIGHTED AND WEIGHTED AVERAGES OF THE MONTHLY PRICES OF TWENTY-FOUR PRODUCTS, YEARS BEGINNING JULY 1, 1910–1932
(July, 1924 to June, 1929 = 100)

Year beginning July 1	Index numbers based on		Difference*	Year beginning July 1	Index numbers based on		Difference*
	Unweighted average of monthly prices	Weighted average of monthly prices			Unweighted average of monthly prices	Weighted average of monthly prices	
1910	71.9	72.2	−0.3	1922	92.6	91.9	0.7
1911	73.3	73.1	0.2	1923	86.8	86.9	−0.1
1912	71.7	73.2	−1.5	1924	101.6	102.8	−1.2
1913	75.9	75.2	0.7	1925	103.2	102.7	0.5
1914	66.3	66.2	0.1	1926	89.7	90.0	−0.3
1915	67.7	67.7	0.0	1927	105.3	105.6	−0.3
1916	88.9	87.5	1.4	1928	100.2	98.9	1.3
1917	109.6	111.4	−1.8	1929	102.7	104.0	−1.3
1918	128.4	126.0	2.4	1930	76.2	74.9	1.3
1919	127.8	128.2	−0.4	1931	53.9	53.7	0.2
1920	101.1	102.1	−1.0	1932	46.6	46.0	0.6
1921	91.8	93.3	−1.5				

* Excess of unweighted over weighted averages.

Sources of data: Calculations by the author based on data presented in tables 7, 41, and 43.

ing and not weighting the monthly prices would be even less. The price series for the eleven products for which monthly price data were not used would have the same effect on each index-number series, and, by displacing a part of the influence of the twenty-four products, would tend to reduce the differences between corresponding index numbers.

In view of the relatively small differences between index numbers based on the unweighted averages of monthly prices and those based on monthly prices weighted with the values given in table 1 (and the questionable applicability of these weights to the situation in a given year), unweighted averages of the monthly prices have been used in the construction of the indexes which follow.

CALENDAR-YEAR VERSUS CROP-YEAR ANNUAL AVERAGE PRICES

Most annual index numbers of prices are for the calendar years (years beginning January 1). This is due, in part, to the fact that most of the basic statistical data for index numbers have been compiled on this basis. Furthermore, there is no one common dividing line between two successive twelve-month periods which is satisfactory for all index-number purposes—hence the division made by the Gregorian calendar is the one most commonly used.

Calendar-year annual prices for many agricultural products are limited in their usefulness because they are based on the prices for a portion of each of two crops. Since the prices of agricultural products are dependent, to a very large extent, on the supply factor, calendar-year annual averages of monthly prices may readily be misinterpreted. The marketing season for barley in California, for example, extends from about July 1 in one year to July 1 in the following year. The calendar-year annual price of barley in California for 1922, therefore, pertains in part to the portion of the crop harvested in 1921 but sold in 1922 and in part to that portion of the 1922 crop which was sold before January 1, 1923.

Because of the character of the seasons and the types of products grown, a fair approximation to a crop-year period, which is satisfactory for most crops in California, can be obtained by considering July 1 as the dividing line between successive crop years. A large portion of each of the more important crops produced in the state is harvested in the last half of the calendar year and marketed before July 1 of the following year.

In the construction of annual farm-price indexes for California, price series for both the calendar years (years beginning January 1) and the approximate crop years (years beginning July 1) were com-

piled. Index numbers based on each of these price series were then calculated. For most purposes, the index numbers for the approximate crop years will be more satisfactory than those for the calendar years. The calendar-year index numbers will be required in comparisons with other indexes for which approximate crop-year data are not available.

METHOD OF CONSTRUCTING THE ANNUAL INDEX-NUMBER SERIES

In the construction of an index number of prices a number of factors need to be taken into consideration.[7] Among these are: (1) the commodities to include, (2) the weight to assign different commodities, (3) the period which is to serve as a base, and (4) the type of average to employ in combining the prices of the different commodities in an index number.

Commodities Included.—It is impractical to attempt to include the prices of all farm products produced in California in a farm-price index for the state. Many products are of such relatively minor importance as a source of cash income that the inclusion of their prices would not have sufficient influence on the index to warrant the effort required to obtain adequate price series for them. Furthermore, for many of the products, sufficiently reliable price quotations over a period of years are not available.

Fortunately, a fairly reliable measure of the changes in the prices of the whole group of products can be obtained by selecting the most important commodities from the group and including only those in the index. A sample, including products which are representative of the various sources of the cash income of the farmers of the state and which account for a large percentage of this income can be expected to give results which do not differ significantly from the index that would be obtained by including all products.

The twenty-four products for which monthly farm-price data for

[7] For a more complete discussion of the construction of index numbers of farm prices, readers are referred to the following:

Bean, L. H., and O. C. Stine. Four types of index numbers of farm prices. Jour. Amer. Statis. Assoc. 19:30–35. 1924.

Black, A. G., and D. D. Kittredge. State indexes of prices of farm products. Jour. Farm Econ. 10:312–330. 1928.

More general discussions of index-number construction include:

Fisher, Irving. The making of index numbers. 3d ed. rev. 538 p. Houghton Mifflin Company, New York. 1927.

Persons, Warren M. The construction of index numbers. 90 p. Houghton Mifflin Company, New York. 1928.

King, W. I. Index numbers elucidated. 226 p. Longmans, Green and Company, New York. 1930.

Mitchell, Wesley C. The making and using of index numbers. U. S. Dept. Labor Bur. of Labor Statis. Bul. 284:7–114. 1921.

TABLE 6

AVERAGE ANNUAL CASH INCOME RECEIVED BY PRODUCERS IN CALIFORNIA FROM THE SALE OF FARM PRODUCTS DURING THE FIVE-YEAR PERIOD, 1924–1928, INCLUSIVE

Product*	Average annual cash income, 1924-1928	
	Dollars	Per cent of total
Meat animals: total	58,719,800	10.2
Beef cattle, Veal calves	33,594,800	5.8
Hogs	12,758,600	2.2
Sheep, Lambs	12,366,400	2.2
Dairy products: total	64,500,800	11.2
Milk, Milk fat, Butter	64,500,800	11.2
Poultry products: total	36,945,800	6.4
Eggs	30,175,600	5.2
Chickens	6,770,200	1.2
Other livestock and livestock products: total	8,372,000	1.5
Wool	7,261,600	1.3
Horses	389,800	0.1
Miscellaneous	720,600	0.1
All livestock and livestock products: total	168,538,400	29.3
Grains: total	40,425,000	7.0
Barley	15,187,000	2.6
Wheat	13,037,600	2.3
Rice	7,981,800	1.4
Oats	1,155,400	0.2
Corn	633,800	0.1
Miscellaneous	2,429,400	0.4
Field crops other than grain: total	64,994,800	11.3
Hay, Alfalfa	17,615,600	3.1
Cotton	12,031,800	2.1
Potatoes	8,411,200	1.5
Beans	16,677,000	2.9
Sugar beets	4,944,800	0.8
Miscellaneous	5,314,400	0.9
Fruits: total	217,583,800	37.8
Oranges	77,706,600	13.5
Lemons	19,515,600	3.4
Apples	10,469,400	1.8
Fruits (*Continued*)		
Grapes, Raisins	49,000,000	8.5
Prunes	16,826,000	2.9
Peaches	12,814,800	2.3
Pears	8,300,000	1.4
Apricots	9,187,400	1.6
Cherries	2,351,600	0.4
Miscellaneous	11,412,400	2.0
Nuts: total	15,800,200	2.7
Walnuts	12,080,000	2.1
Almonds	3,720,200	0.6
Truck crops: total	60,810,200	10.6
Nursery products: total	2,929,000	0.5
Forest products: total	2,179,400	0.4
Greenhouse products: total	2,177,000	0.4
All crops: total	406,899,400	70.7
All products: total	575,437,800	100.0

* All of the specific products listed are included in the California farm-price index.

Sources of data:

U. S. Dept. Agr. Bur. Agr. Econ. Farm value, gross income, and cash income from farm production. Part III. State summaries of the income estimates, 1924-1928. p. 18-20. August, 1930. (Mimeo.)

U. S. Dept. Agr. Bur. Agr. Econ. Farm value, gross income, and cash income from farm production. Part III. State summaries of the income estimates, 1928-1929. p. 8-9. November, 1930. (Mimeo.)

California are available accounted for between 60 and 65 per cent of the estimated gross cash income of the farmers of the state during the five-year period, 1924–1928, inclusive. A large portion of the income from fruits was not represented. In order to include the prices of as many products as are needed to account for a large percentage of the agricultural income and to give due weight to fruit prices in the index, price series for eleven additional products, seven of them fruits, are included.

The thirty-five commodities represented in the California farm-price index accounted for between 85 and 90 per cent of the estimated gross cash income from agriculture in California during the 1924–1928 period. The proportion of the total income during those five years contributed by the various products is shown in table 6. It can be seen from the data presented that, with the exception of truck crops, the products included in the index represent a fair cross section of California agriculture. Unfortunately, owing to the unavailability of satisfactory data, truck-crop prices are not included in the index. Changes in the character of the various truck crops produced, in the form in which they are sold, and in the method of packing and type of package used, make it extremely difficult to secure comparable price data for any length of time.

Weight Assigned Different Commodities.—Commodities vary greatly in importance. Some products may be considered more important than others because they require a larger percentage of the land resources in a given area or because a larger physical quantity of the commodity is produced during a given period, or for other reasons. A large number of criteria may be used in judging the importance of a particular product.

In an index number the importance of the various products is accounted for by assigning a weight, or series of weights, to each commodity. In an index number of prices these weights are usually related, in some way or other, to the income derived from the sale of the product. If the index numbers are derived from the aggregate values of a fixed quantity of goods, quantity weights are generally used. If, on the other hand, averages of price relatives are calculated, arbitrary values (usually percentages) of any character which bear some relation to each other may be used. Occasionally a series of weights, rather than a single weight, are assigned to each commodity. This is done when an attempt is being made to take into account the changing importance of products from time to time.

In the California farm-price index a single fixed weight is assigned to each product. These weights are based on the estimated annual quantities of the products marketed during the five-year period, 1924–1928, inclusive. Estimates of these quantities (table 7) were obtained from

various sources. Data for twenty-six of the products were estimated as follows:[8]

Beef cattle, hogs, sheep, and lambs: Estimates of net disappearance (less deaths) in California.

Veal calves: Estimates of the shipments out of the state plus the slaughter in California.

TABLE 7

WEIGHTS ASSIGNED TO PRODUCTS IN THE CALIFORNIA FARM-PRICE INDEX, BASED ON ESTIMATED ANNUAL QUANTITIES MARKETED DURING THE FIVE-YEAR PERIOD, 1924–1928, INCLUSIVE

Product	Estimated annual quantity marketed		Product	Estimated annual quantity marketed	
	Quantity	Unit		Quantity	Unit
Beef cattle	3,348,000	100 pounds	Alfalfa	1,032,000	tons
Veal calves	828,000	100 pounds	Cotton	63,900,000	pounds
Hogs	1,340,000	100 pounds	Potatoes	6,197,000	bushels
Sheep	373,000	100 pounds	Beans	4,371,000	bushels
Lambs	809,000	100 pounds	Sugar beets	550,000	tons
Milk*	10,766,000	100 pounds	Oranges	26,324,000	boxes
Milk fat	70,700,000	pounds	Lemons	6,753,000	boxes
Butter	775,000	pounds	Apples	8,250,000	bushels
Eggs	100,067,000	dozen	Grapes‡	1,057,000	tons
Chickens	22,827,000	pounds	Peaches§	395,500	tons
Wool	21,208,000	pounds	Pears‖	165,000	tons
Horses	4,440	head	Apricots¶	165,000	tons
Barley	19,440,000	bushels	Cherries**	4,500	tons
Wheat	9,887,000	bushels	Raisins††	237,500	tons
Rice	6,575,000	bushels	Prunes††	176,000	tons
Oats	1,933,000	bushels	Walnuts	30,000	tons
Corn	519,000	bushels	Almonds	11,500	tons
Hay†	270,000	tons			

* Milk sold as market milk.
† Hay other than alfalfa.
‡ All grapes less fresh equivalent of raisins dried.
§ Canned and dried peaches only.
‖ Bartlett variety only.
¶ Canned and dried apricots only.
** Canned cherries only.
†† Dried tons.

Sources of data: See text, pages 18 to 20, and footnotes 8 to 17.

Milk, milk fat, and butter: Estimates of the milk equivalent sold (subdivided into quantities sold as farm butter and as other milk products) in California. Estimates of the quantities sold as market milk were made by the author, based on the percentage utilization of milk fat produced in California as given in table 17 of Bulletin 514.[9] Estimates of the quantities of milk fat sold were made by deducting the estimated quantities of milk equivalent sold as market milk from that portion sold as milk products other than farm butter and converting the results to a milk-fat basis. The estimates (as made by the Bureau of Agricultural Economics) of the milk

[8] U. S. Dept. Agr. Bur. Agr. Econ. Farm value, gross income, and cash income from farm production. Part I. Estimates by commodities and by states, together with production, disposition, and price data used, 1924–1928. p. 1–354. March, 1930. (Mimeo.)

[9] Voorhies, E. C. Dairy products. California Agr. Exp. Sta. Bul. 514:43. 1931.

equivalent sold as farm butter in California were converted to a butter basis by considering 3.85 per cent (an estimate also made by the Bureau of Agricultural Economics) as the average milk-fat content of the milk produced in California and 82.5 per cent (the minimum allowable by state law) as the milk-fat content of butter.

Eggs: Estimates of the number sold (except for hatching) in California.

Chickens: Estimates of the number sold in California. An estimate of 2 pounds as the average live weight, based on the opinions of persons familiar with the poultry industry in California, was used in converting these data to a weight basis.

Wool: Estimates of the production in California.

Horses: Estimates of the net number sold in California.

Barley, wheat, rice, oats, and corn: Estimates of the quantity sold or for sale in California.

Hay and alfalfa: Estimates of all hay sold or for sale in California. The production data for alfalfa and for other hay, as reported by the California Crop Reporting Service, served as a basis for estimating the quantities of each type sold or for sale.

Cotton: Estimates of the production in California.

Potatoes and beans: Estimates of the quantities sold or for sale in California.

Sugar beets: Estimates of the quantities sold for sugar in California.

Oranges, lemons, and apples: Estimates of the quantities sold or for sale in California.

Data for the other products were estimated as follows:

Grapes:[10] Estimates of the harvested production of all grapes in California less fresh equivalent of raisins dried.

Peaches:[11] Estimates of the harvested production in California less fresh shipments.

Pears:[12] Estimates of the harvested production in California less estimated production of varieties other than Bartletts (11 per cent of total production harvested).

Apricots:[13] Estimates of the harvested production in California less fresh shipments.

Cherries:[14] Estimates of the quantities canned in California.

Raisins:[15] Estimates of the quantities dried in California.

Prunes:[16] Estimates of the harvested production in California.

Walnuts and almonds:[17] Estimates of the production in California.

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[10] Shear, S. W. Grapes. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[11] Wellman, H. R. Peaches. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[12] Shear, S. W., and H. R. Wellman. Pears. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[13] Wellman, H. R., and C. J. Poole. Apricots. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[14] Wellman, H. R., and C. J. Poole. Cherries. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[15] Shear, S. W. Grapes. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[16] Shear, S. W. Prunes. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

[17] Wellman, H. R., and. H. E. Erdman. Walnuts. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

Wellman, H. R., and C. J. Poole. Almonds. Outlook charts and tables. California Agr. Exp. Sta. February, 1932. (Mimeo.)

Period Which Is to Serve as a Base.—Most price index numbers express, in percentages, the relation between prices at a specific time and prices in a base period which is designated as 100. The choice of this base period depends upon a number of considerations, among which are the following: (1) the purpose of the index number, (2) the availability of a period during which price interrelations were sufficiently stable, and (3) the comparative accuracy of the price data for different years.

A farm-price index serves two purposes which need to be taken into consideration in the selection of a base period. First, it provides a basis for comparing the general movements in farm prices over a long period of time with movements in other price series—wholesale prices, retail prices, wages, taxes, real-estate prices, rents, etc. Secondly, it serves as a base for judging changes in the farm prices of individual products. During the years since 1910, the first of these purposes has been most satisfactorily served by the selection of the 1910–1914 period as a base.[18] During that period the ratio of the wholesale prices of farm products to the wholesale prices of nonagricultural commodities was at the approximate level to which, over a long period of years, there has been a tendency to return. Moreover, the serious maladjustments between groups of prices that follow periods of monetary inflation and deflation did not exist at that time. If, on the other hand, a farm-price index is constructed for use in judging changes in the farm prices of individual products, its purpose is most satisfactorily achieved when the base period is comparatively near the time of such price changes, when it is a period of stable prices in general, and is represented by price series which are as accurate as can be obtained. The 1924–1928 period exhibits the qualifications most desired in obtaining a basis for judging recent changes in farm prices in California.

In selecting a base period for a price index, extending from 1910 to date, in which price interrelations can be considered sufficiently stable for that purpose, one is practically limited to two periods, 1910 to 1915 and 1922 to 1929. The first of these periods is characterized by what were undoubtedly the most stable economic conditions in existence in this country since 1910. The second period, during which a degree of economic stability was attained, came between the two major financial crises experienced since the War.

Generally speaking, the accuracy of price data increases with the passage of time. Better methods of collecting price quotations are developed, the size of the samples upon which prices are based are enlarged,

[18] A good discussion of the use of the 1910–1914 period as a base for price indexes was published recently: Stine, O. C. [Discussion.] Jour. Farm. Econ. 15:254–259. 1933.

and more attention is given to bias in sampling, errors in reporting, and other related problems. The accuracy of much of the price data in California has improved in recent years owing to the increased attention given to the problem by research workers in response to the needs of the farmers and marketing organizations of the state.

In the construction of the California farm-price index, a decision was made to calculate two indexes, one of which would be based on the pre-war period, 1910–1914, and the other on the five post-war years, 1924 to 1928, inclusive. With an index available based on each of the two periods, the one may be chosen which best serves a particular purpose.

Type of Averaging Process Employed in Combining Prices.—Two general methods have been used in combining the prices of several products in an index number. In one method the price relative (ratio of the price at a given time to the corresponding price in the base period) of each product is calculated. Then these relatives, one for each product, are combined by some averaging process into a single ratio, or index number. In another method price relatives are not calculated. Each index number is obtained by relating the aggregate value of the products included in the index at a given time to the corresponding aggregate value in the base period.

Most state indexes of the prices of farm products are of the aggregative type. The monthly index of Missouri farm prices,[19] for example, was constructed by calculating the aggregate value of a fixed quantity of thirteen products (691,500 hundredweight of hogs, 8,333 head of horses, etc.) for a given month, and expressing this value as a percentage of the corresponding total value of the same quantities in the base period. Since the quantity of each product was held constant, any change in the aggregate value (price times quantity) was due entirely to price changes. In the Minnesota farm-price index,[20] a somewhat different procedure was followed, although the aggregative method was used. A formula was employed which combined the weightings of the quantities sold in the base period with the quantities sold in the current period.

The California farm-price index is of the aggregative type using fixed weights. The index number for a given year is obtained by multiplying the price of each commodity in that year by its weight (table 7), adding the products, and dividing the sum by the corresponding value for the base period. The average annual base-period values used in the construction of the several indexes for California are given in table 8.

[19] Cowan, D. R. G. Missouri farm prices and purchasing power. Missouri Agr. Exp. Sta. Research Bul. 84:1–34. 1926.

[20] Black, A. G., and D. D. Kittredge. Minnesota agricultural indexes of prices, quantities, and cash incomes, 1910–1927. Minnesota Agr. Exp. Sta. Tech. Bul. 72: 1–90. 1930.

TABLE 8

AVERAGE ANNUAL AGGREGATE VALUE OF FARM PRODUCTS IN CALIFORNIA DURING EACH OF THE PERIODS USED AS A BASE FOR THE INDEX NUMBERS OF FARM PRICES

Product	Average annual aggregate value, calendar years, 1924-1928	Average annual aggregate value, July, 1924 to June, 1929	Average annual aggregate value, calendar years, 1910-1914	Average annual aggregate value, July, 1910 to June, 1915
	dollars	*dollars*	*dollars*	*dollars*
Beef cattle	25,083,400	26,114,400	20,195,200	20,422,600
Veal calves	7,977,000	8,301,600	5,585,600	5,736,400
Hogs	14,651,400	15,010,600	9,870,400	9,669,600
Sheep	2,983,800	3,019,800	1,792,000	1,813,400
Lambs	9,551,000	9,648,000	4,642,200	4,700,200
Milk	28,228,400	28,228,600	26,764,200	26,376,600
Milk fat	35,378,400	35,491,200	23,967,400	23,656,200
Butter	373,600	373,200	242,000	240,400
Eggs	33,682,600	33,802,600	29,219,800	28,879,400
Chickens	5,798,200	5,866,600	3,387,400	3,401,400
Wool	7,096,200	7,053,800	2,969,400	3,007,200
Horses	391,600	386,600	621,600	612,000
Barley	15,692,000	15,742,600	12,783,600	12,717,600
Wheat	13,434,400	13,507,800	9,434,200	9,570,600
Rice	8,784,200	8,784,200	5,667,600	5,667,600
Oats	1,226,400	1,225,800	1,037,200	1,015,600
Corn	640,600	642,200	447,200	452,400
Hay	3,828,400	3,872,800	3,045,800	2,990,000
Alfalfa	15,758,400	15,859,800	10,002,000	9,975,200
Cotton	13,061,400	12,307,000	6,811,800	6,811,800
Potatoes	9,004,000	8,658,400	4,986,200	5,047,800
Beans	16,906,800	17,615,400	11,827,800	12,046,400
Sugar beets	4,830,200	4,830,200	—*	—
Oranges	88,027,400	88,674,600	—	—
Lemons	19,664,600	20,475,000	—	—
Apples	11,995,800	11,698,600	7,722,000	7,557,000
Grapes	27,482,000	27,482,000	13,741,000	13,741,000
Peaches	12,497,800	12,497,800	8,226,200	8,226,200
Pears	8,778,000	8,778,000	6,435,000	6,435,000
Apricots	9,570,000	9,570,000	6,270,000	6,270,000
Cherries	727,200	797,400	513,000	523,800
Raisins	14,107,200	14,107,200	16,197,600	16,197,600
Prunes	18,304,000	18,304,000	19,536,000	19,536,000
Walnuts	12,528,000	12,528,000	7,956,000	7,956,000
Almonds	3,841,000	3,841,000	2,930,200	2,930,200
Meat animals	60,246,600	62,094,400	42,085,400	42,342,200
Dairy products	63,980,400	64,093,000	50,973,600	50,273,200
Poultry products	39,480,800	39,669,200	32,607,200	32,280,800
Grains	39,777,600	39,902,600	29,369,800	29,423,800
Field crops other than grains	63,389,200	63,143,600	36,673,600†	36,871,200†
Fruits	211,154,000	212,384,600	78,640,800‡	78,486,600‡
Livestock and livestock products	171,195,600	173,297,000	129,257,200	128,515,400
Crops	330,689,800	331,799,800	155,570,400§	155,667,800§
All products	501,885,400	505,096,800	284,827,600§	284,183,200§

* Dashes indicate data not available.

† Not including sugar beets.

‡ Not including oranges and lemons.

§ Not including sugar beets, oranges, and lemons.

Sources of data: Calculations by the author based on data presented in tables 7, 40, 41, and 44.

The prices of oranges and lemons prior to 1912, and of sugar beets prior to 1916, are not available, and, hence, did not enter into the construction of the indexes for those years. When the post-war base period was used, the index numbers for 1910 and 1911 were obtained by dividing the aggregate values of all products except oranges, lemons, and sugar beets for those years by the aggregate value of the same products during the base period. In like manner, the index numbers for 1913, 1914, and 1915 are based on all products except sugar beets.

When the 1910–1914 period was used as a base, the prices of oranges, lemons, and sugar beets were "chained" into an index including all other prices. The data presented in table 9 illustrate the procedure followed in "chaining" the prices of these three products into the index-number series when 1910–1914 = 100. Index numbers (col. 2), including the prices of all products except oranges, lemons, and sugar beets and using 1910–1914 as the base period, are calculated from the aggregate values of those products (col. 1). The aggregate value of all products (col. 3), including oranges, lemons, and sugar beets, for each year is expressed as a percentage of the aggregate value of these products in the preceding year (col. 4). Each of these percentages, or link relatives, is then multiplied by the index number for the preceding year (cols. 2 and 5) to obtain a chain index (col. 5). The substitution of the values in this chain index for the index numbers for corresponding years in column 2, and the adjustment of these values to an average of 100 for the five years, 1910–1914 (col. 7), completes the process.

AN INTERPRETATION OF THE INDEX-NUMBER SERIES

CALIFORNIA FARM PRICES OF ALL PRODUCTS COMBINED AND OF MAJOR GROUPS OF PRODUCTS

The index of California farm prices for the years beginning July 1, and based on the five pre-war years, are presented in table 10.[21] The products included in each of the groups designated in the tables are as follows:

Meat animals: beef cattle, veal calves, hogs, sheep, and lambs.

Dairy products: milk, milk fat, and butter.

Poultry products: eggs and chickens.

Grains: barley, wheat, rice, oats, and corn.

Field crops other than grains: hay, alfalfa, cotton, potatoes, beans, and sugar beets (since 1916).

[21] Indexes for the years beginning July 1, based on the period from July, 1924 to June, 1929, and for the calendar years, based on the 1910–1914 and the 1924–1928 periods, are presented in tables 45, 46, and 47 in Appendix B.

TABLE 9

ILLUSTRATION OF METHOD USED IN ADDING THE PRICES OF ORANGES AND LEMONS IN 1912, AND OF SUGAR BEETS IN 1916, TO THE INDEX OF FARM PRICES IN CALIFORNIA, WHEN 1910–1914 = 100

Year beginning January 1	Aggregate values of all products except oranges, lemons, and sugar beets	Index numbers of the prices of all products except oranges, lemons, and sugar beets (1910-1914=100)	Aggregate values of all products, including oranges, lemons, and sugar beets*	Link relatives of the aggregate values of all products	Chain index of the prices of all products	Index numbers of the prices of all products	
						Unadjusted	(1910-1914=100)
	1	*2*	*3*	*4*	*5*	*6*	*7*
1910	$277,762,000	97.5	$277,762,000	.....	.....	97.5	95.7
1911	286,289,000	100.5	286,289,000	.....	.....	100.5	98.8
1912	278,801,000	97.9	343,709,000	.....	.....	97.9	96.1
1913	302,647,000	.....	405,291,000	117.9	115.4	115.4	113.2
1914	278,639,000	.....	344,275,000	84.9	98.0	98.0	96.2
1915	272,042,000	.....	331,277,000	96.2	94.3	94.3	92.6
1916	327,876,000	.....	410,781,000	123.0†	116.0	116.0	113.8
1917	$439,422,000	.....	$516,953,000	125.8	145.9	145.9	143.2

* Oranges and lemons were added in 1912; sugar beets in 1916.

† Aggregate value of all products, except sugar beets, in 1916 was $407,316,000. This figure was used in the calculation of the link relative for 1916.

Sources of data: Calculations by the author based on data presented in tables 7, 40, 41, and 44.

Fruits: oranges (since 1912), lemons (since 1912), apples, grapes, peaches, pears, apricots, cherries, raisins, and prunes.

Livestock and livestock products: meat animals, dairy products, poultry products, wool, and horses.

TABLE 10

ANNUAL INDEX NUMBERS OF FARM PRICES, CALIFORNIA, YEARS BEGINNING JULY 1, 1910–1932

(July, 1910 to June, 1915 = 100)

Year beginning July 1	All products	Livestock and livestock products				Crops			
		All	Meat animals	Dairy products	Poultry products	All	Grains	Field crops other than grains	Fruits
1910	97	101	100	102	100	94	87	107	93
1911	103	98	90	107	98	108	106	99	118
1912	97	101	98	107	94	95	103	107	88
1913	108	101	106	95	107	111	101	103	112
1914	95	99	106	90	102	92	103	84	88
1915	94	100	103	92	103	91	97	106	84
1916	126	117	125	105	119	130	140	177	116
1917	155	151	165	132	144	156	208	210	132
1918	186	173	182	155	175	192	203	197	186
1919	212	177	176	170	179	229	247	253	218
1920	186	146	141	146	154	207	156	192	221
1921	152	122	115	127	124	167	111	137	183
1922	146	131	124	135	124	154	115	154	160
1923	127	128	120	132	123	126	115	183	111
1924	145	130	128	121	135	153	170	188	138
1925	145	139	146	131	132	148	138	170	141
1926	130	131	143	126	118	129	120	141	122
1927	142	132	150	127	110	147	135	149	147
1928	134	141	165	131	119	129	115	164	118
1929	152	132	153	122	122	163	112	173	168
1930	104	100	115	95	87	105	80	116	104
1931	81	78	81	76	77	82	67	84	82
1932	64	65	66	63	69	63	47	74	62

Sources of data: Calculations by the author based on data presented in tables 7, 8, 41, and 44.

Crops: grains, field crops other than grains, fruits, walnuts, and almonds.

All products: livestock and livestock products and crops.

According to these index numbers, the level of farm prices in California was lower in the year beginning July 1, 1932, than in any other year during the period covered by the index (fig. 1). Between 1910 and 1915, prices were comparatively stable. In 1915 they began to rise and rose rapidly until 1919–20 when they reached a peak at levels more than double the average for July, 1910 to June, 1915. From then until 1923, farm prices in California declined at a rate approximately equal to that

of the preceding advance. Between 1923 and 1929, they were again comparatively stable. By 1931, however, they had declined to levels below that of the pre-war base period.

The farm prices of meat animals and of poultry products followed fairly closely the course of the all-products index until 1918, when meat-animal prices reached their peak (fig. 2). Between 1918 and 1924, both

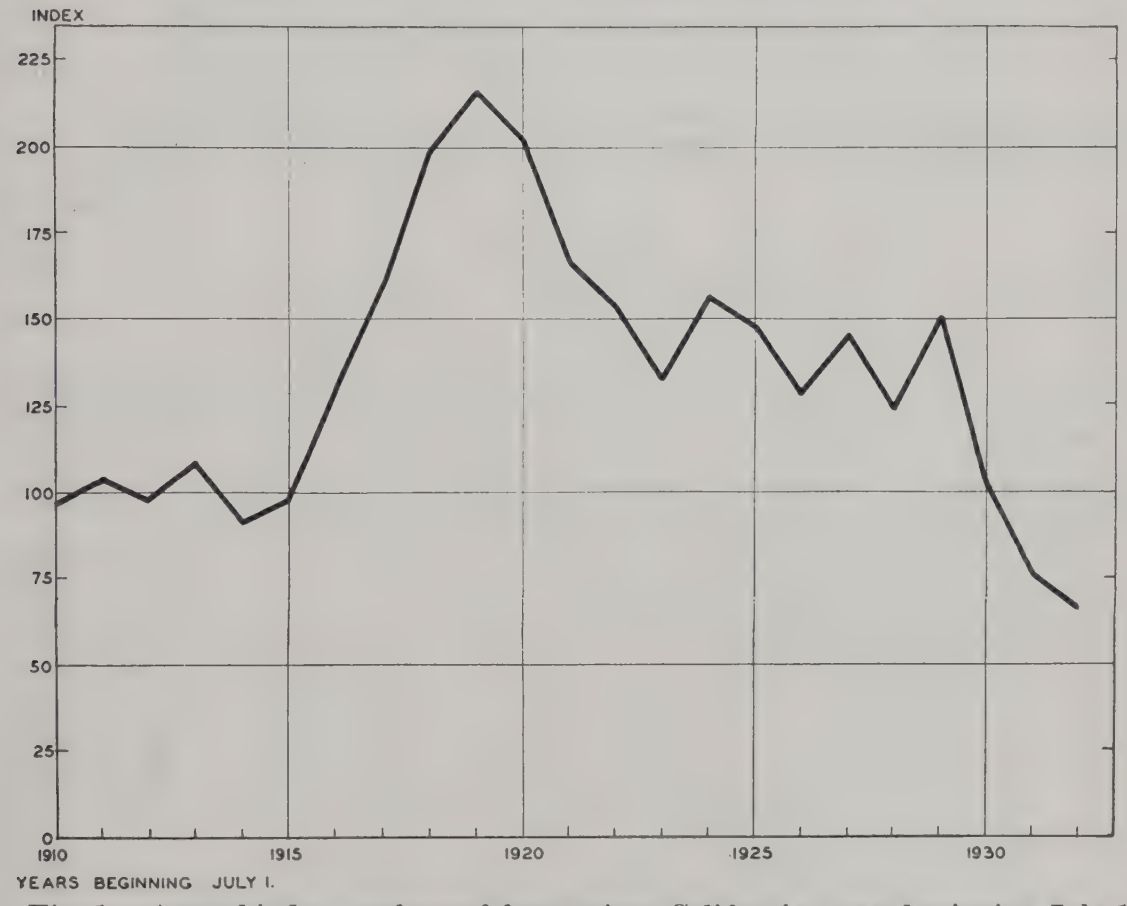


Fig. 1.—Annual index numbers of farm prices, California, years beginning July 1, 1910–1932. (July, 1910 to June, 1915 = 100.)

During the War, farm prices in California were over twice as high as they were between 1910 and 1914. Since 1930, farm prices have averaged lower than pre-war levels. (Data from table 10.)

groups of prices remained together and below the average of the farm prices of all products in California. Supplies of practically all classes of important meats were relatively lower between 1926 and 1929 than in earlier years. These resulted in relatively higher farm prices for meat animals, as a group, than for all products combined. Poultry products continued low in price as compared with other products, until 1931. In the year beginning July 1, 1932, the farm prices of poultry products (eggs and chickens) in California were higher, in relation to the farm prices of other products, than in any other year since 1915.

The farm prices of grains rose very rapidly in the early stages of the World War because of the war demands for the staple food products

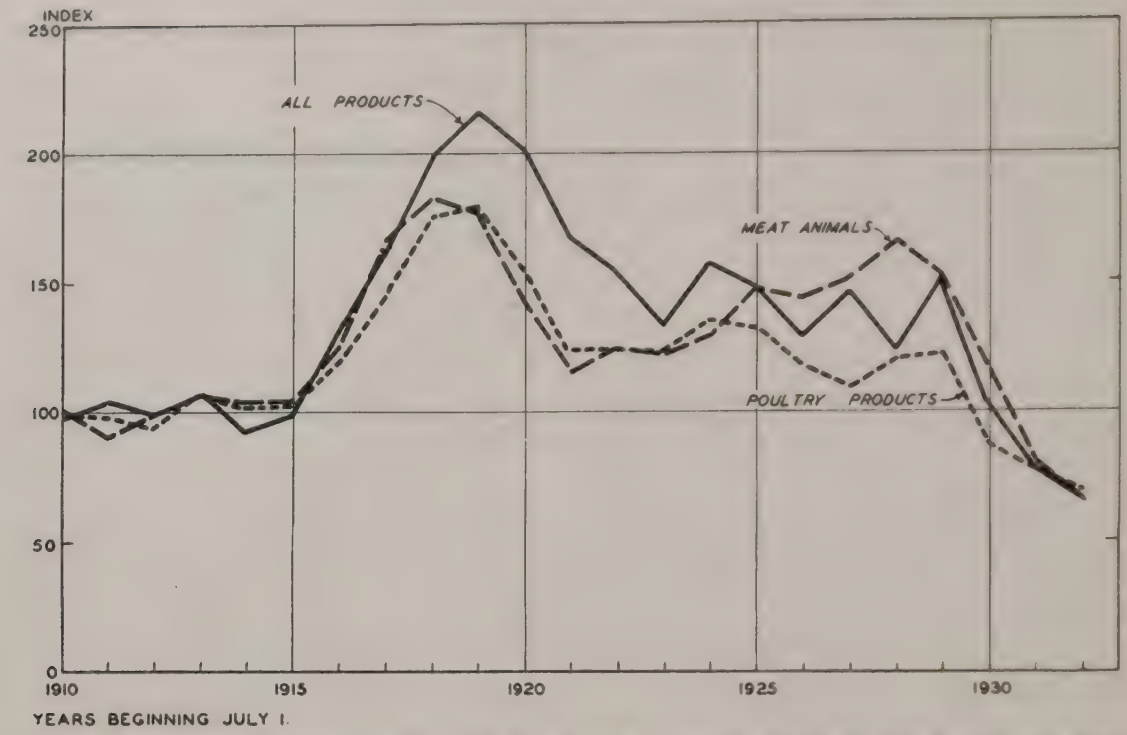


Fig. 2.—Annual index numbers of the farm prices of meat animals, poultry products, and all products, California, years beginning July 1, 1910–1932. (July, 1910 to June, 1915 = 100.)

The prices of poultry products were low as compared with the prices of other farm products in California from 1916 until 1931. Meat animals were relatively high in price from 1926 to 1931. (Data from table 10.)

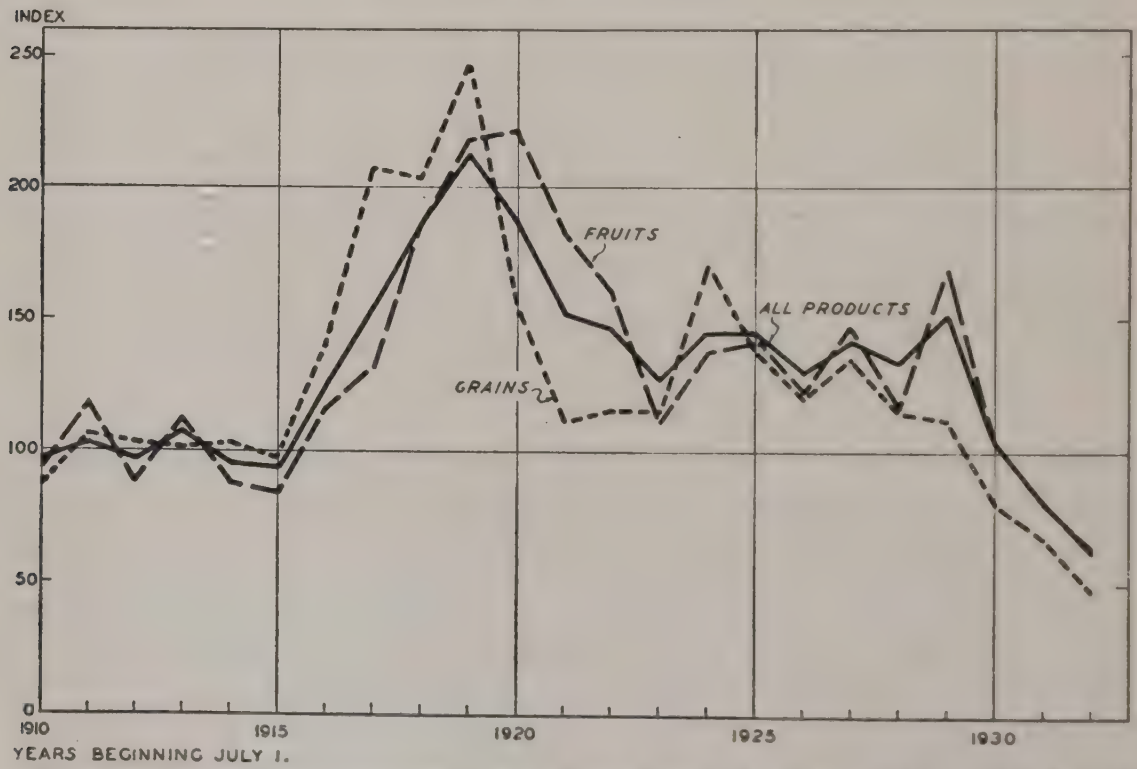


Fig. 3.—Annual index numbers of the farm prices of fruits, grains, and all products, California, years beginning July 1, 1910–1932. (July, 1910 to June, 1915=100.)

After the War, grain prices fell rapidly to within 15 per cent of pre-war levels. The prices of fruits, especially grapes, remained very high as compared with the prices of other products. (Data from table 10.)

(fig. 3). Between 1919 and 1921, they fell even more rapidly to within 15 per cent of the pre-war levels. After this sharp decline, grain prices recovered considerably, reaching, in 1924–25, 170 per cent of the average for July, 1910 to June, 1915. Since 1924, they have declined at an average rate of approximately 14 per cent a year.

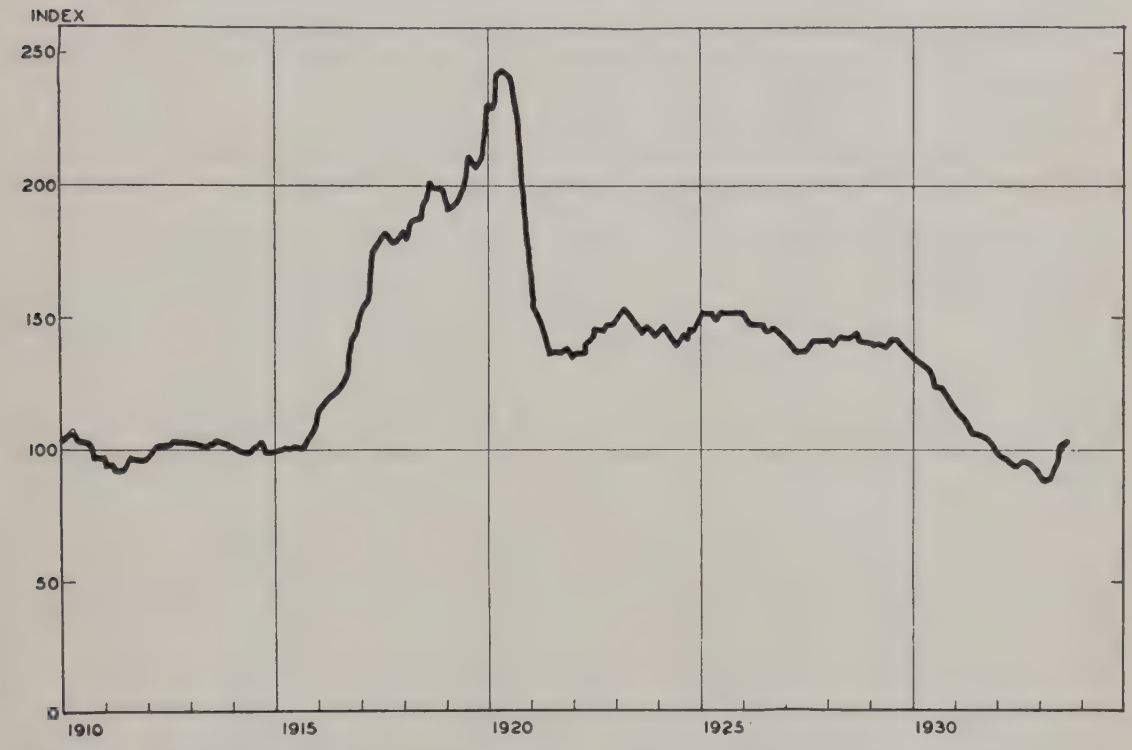


Fig. 4.—Monthly index numbers of the wholesale prices of all commodities, United States, 1910–1933. (1910–1914 = 100.)

The general level of commodity prices in the United States was comparatively stable between 1910 and 1915 and from 1921 until 1929. (Data from table 11.)

The farm prices of fruits in California lagged behind grain prices during the War period and reached their highest level after grain prices had fallen (fig. 3). Fruit growers, as a group, did not experience the first post-war depression of 1921. Grape prices, in particular, were very favorable to the producer. Since 1923, however, fruit prices have followed rather closely the prices of other agricultural products, and, because of the importance of fruits in California, have accounted for a large proportion of the year-to-year fluctuations in the index for all products.

GENERAL LEVEL OF PRICES IN THE UNITED STATES

The major movements in the annual indexes of farm prices in California since 1910 have been governed largely by the changes in the general level of prices in the United States. Changes in the general level of prices represent variations in the exchange value, or purchasing power, of money.

One of the more generally accepted measures of the general level of prices in the United States is the all-commodity index of wholesale prices constructed by the Bureau of Labor Statistics of the United States Department of Labor. The monthly index numbers for the years 1910 to 1933, inclusive, are presented in table 11 and figure 4.

TABLE 11

MONTHLY INDEX NUMBERS OF THE WHOLESALE PRICES OF ALL COMMODITIES, UNITED STATES, 1910–1933*
(1910–1914 = 100)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1910	104	104	106	107	105	104	104	103	102	99	97	97	103
1911	97	94	95	92	92	92	93	96	97	97	96	95	95
1912	96	97	99	102	102	101	101	102	103	103	103	102	101
1913	103	102	102	102	101	101	102	102	103	103	102	101	102
1914	100	100	99	99	98	98	99	101	103	99	99	98	99
1915	99	100	100	100	101	100	101	100	100	103	105	108	101
1916	112	115	117	119	121	121	122	124	127	133	142	145	125
1917	149	153	157	167	176	178	180	182	180	178	179	180	172
1918	183	179	185	187	187	188	193	196	201	199	199	199	191
1919	196	190	192	194	198	198	206	211	206	207	211	220	202
1920	230	229	232	242	244	243	242	236	227	211	195	176	226
1921	167	153	150	144	141	136	136	137	136	137	138	136	143
1922	134	136	136	136	140	141	145	144	145	145	147	147	141
1923	149	151	153	152	149	147	144	143	146	145	144	143	147
1924	145	146	144	142	140	139	140	142	142	143	145	148	143
1925	150	152	152	149	148	150	152	152	151	151	153	151	151
1926	151	149	147	147	147	147	145	145	146	145	144	143	146
1927	141	140	138	137	138	137	138	139	141	141	141	141	139
1928	141	140	139	141	142	141	142	143	144	141	140	140	141
1929	140	139	140	139	138	139	141	141	140	139	137	136	139
1930	135	134	132	131	130	127	123	123	123	121	119	116	126
1931	114	112	111	109	107	105	105	105	104	103	103	100	107
1932	98	97	96	96	94	93	94	95	95	94	93	91	95
1933	89	87	88	88	92	95	101	102	103	104	104	103	96

* The all-commodity index of wholesale prices, as constructed by the Bureau of Labor Statistics of the United States Department of Labor, converted to the 1910-1914 base.

Sources of data:

1910-1932: Warren, G. F., F. A. Pearson, and H. M. Stoker. Wholesale prices for 213 years, 1720 to 1932. Cornell Memoir **142**: 71. 1932.

1933: U. S. Dept. Agr. Bur. Agr. Econ. The agricultural situation, monthly issues.

According to this series of index numbers, the general level of prices in the United States did not change much between 1910 and 1915. Late in 1915, prices began to rise at a rapid rate, owing to the monetary inflation which accompanied the government's method of financing the War. This rise continued until early in 1920 when, with the resumption of a peace-time fiscal policy, prices started on their return to pre-war levels. Between 1921 and 1929, a period of post-war reconstruction and industrial expansion, prices remained fairly stable at approximately 45 per cent above pre-war levels. Late in 1929, as a climax to the

orgy of stock-market speculation, the deflationary process reappeared, and prices soon reached pre-war levels. In December, 1932, according to the all-commodity index, wholesale prices in the United States were 91 per cent of their 1910–1914 five-year average.

TABLE 12

ANNUAL INDEX NUMBERS OF FARM PRICES, UNITED STATES, YEARS BEGINNING JULY 1, 1910–1932*
(July, 1910 to June, 1915 = 100)

Year beginning July 1	All products	Livestock and livestock products			Crops		
		Meat animals	Dairy products	Poultry products	Grain	Fruit and vegetables	Cotton and cotton-seed
1910	99	93	98	95	92	98	124
1911	98	87	101	98	105	122	91
1912	98	103	101	97	91	88	102
1913	104	110	101	106	95	106	108
1914	101	107	99	104	117	86	75
1915	104	109	98	104	107	99	102
1916	147	142	112	138	168	189	161
1917	193	190	139	169	224	164	250
1918	205	208	162	194	221	173	254
1919	221	189	185	217	240	256	311
1920	153	138	170	191	161	165	152
1921	120	106	137	150	100	177	140
1922	130	110	141	142	108	131	210
1923	133	103	144	141	109	132	244
1924	143	124	131	158	151	135	205
1925	144	143	139	157	136	203	164
1926	130	141	137	148	121	155	115
1927	139	140	138	146	132	163	167
1928	138	157	141	154	116	121	163
1929	134	149	133	152	114	171	141
1930	98	111	109	105	80	126	86
1931	66	72	83	85	50	80	52
1932	56	60	65	79	41	67	55

* Index numbers converted to the July, 1910 to June, 1915 base by considering the unweighted average of the sixty monthly index numbers for this period, on the August, 1909 to July, 1914 base, as equal to 100.

Sources of data:
1910-1930: U. S. Dept. Agr. Yearbook of Agriculture **1931**: 1018-1020. 1931.
1931-1932: U. S. Dept. Agr. Bur. Agr. Econ. The agricultural situation, monthly issues.

FARM PRICES IN CALIFORNIA AND IN THE UNITED STATES

Index numbers of farm prices in the United States, by groups and for all products, are presented in table 12. The various groups include the following products:

Meat animals: beef cattle, calves, hogs, sheep, and lambs.

Dairy products: milk and butter (representing butter, milk fat, and cream sold by farmers).

Poultry products: chickens and eggs.

Grains: wheat, corn, oats, barley, rye, and kafir (since June, 1923).

Fruits and vegetables: apples, oranges, grapefruit, potatoes, sweet potatoes, beans, onions, and cabbage.

Cotton: cotton and cottonseed.

All products: meat animals, dairy products, poultry products, grains, fruits and vegetables, cotton and cottonseed, horses (representing horses and mules), hay, flax, tobacco (since June, 1923), and wool.

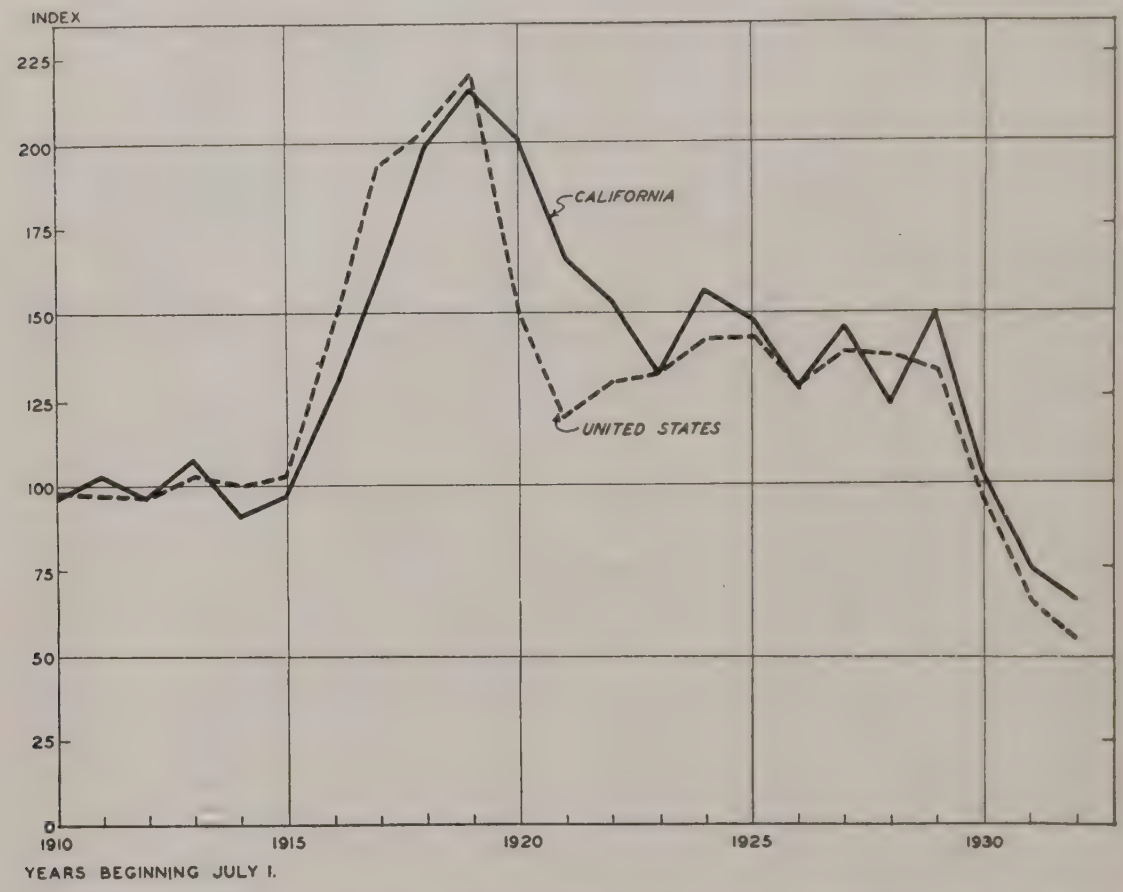


Fig. 5.—Annual index numbers of farm prices in California and in the United States, years beginning July 1, 1910–1932. (July, 1910 to June, 1915 = 100.)
During each of the three periods of major price disturbances in the past two decades, changes in farm prices in the United States, as a whole, have preceded the changes in California farm prices. (Data from tables 10 and 12.)

During the early stages of the War, when prices were rising at a rapid rate, farm-price advances in the United States as a whole preceded the rise in California farm prices (fig. 5). Similarly, in each of the two post-war periods of price deflation, farm prices in California lagged behind farm prices in the United States. These lags in price movements were due, to a large extent, to the character of the commodities included in the two indexes. The United States farm-price index is weighted heavily with the staple products such as cotton, wheat, corn, hogs, beef cattle, and potatoes. The index of farm prices for California, on the other hand, includes many specialty crops of major importance

in the state. When prices rise in periods of inflation or fall in periods of deflation, the staple food products are usually among the first affected.

Although the California farm-price index for grains includes rice, which is not included in the United States index, and the United States index includes the prices of rye, the indexes of grain prices for the United States and for California are very similar (fig. 6). Grains were relatively lower in price in California between 1914 and 1918, and relatively somewhat higher between 1921 and 1924, than in the United States as a whole.

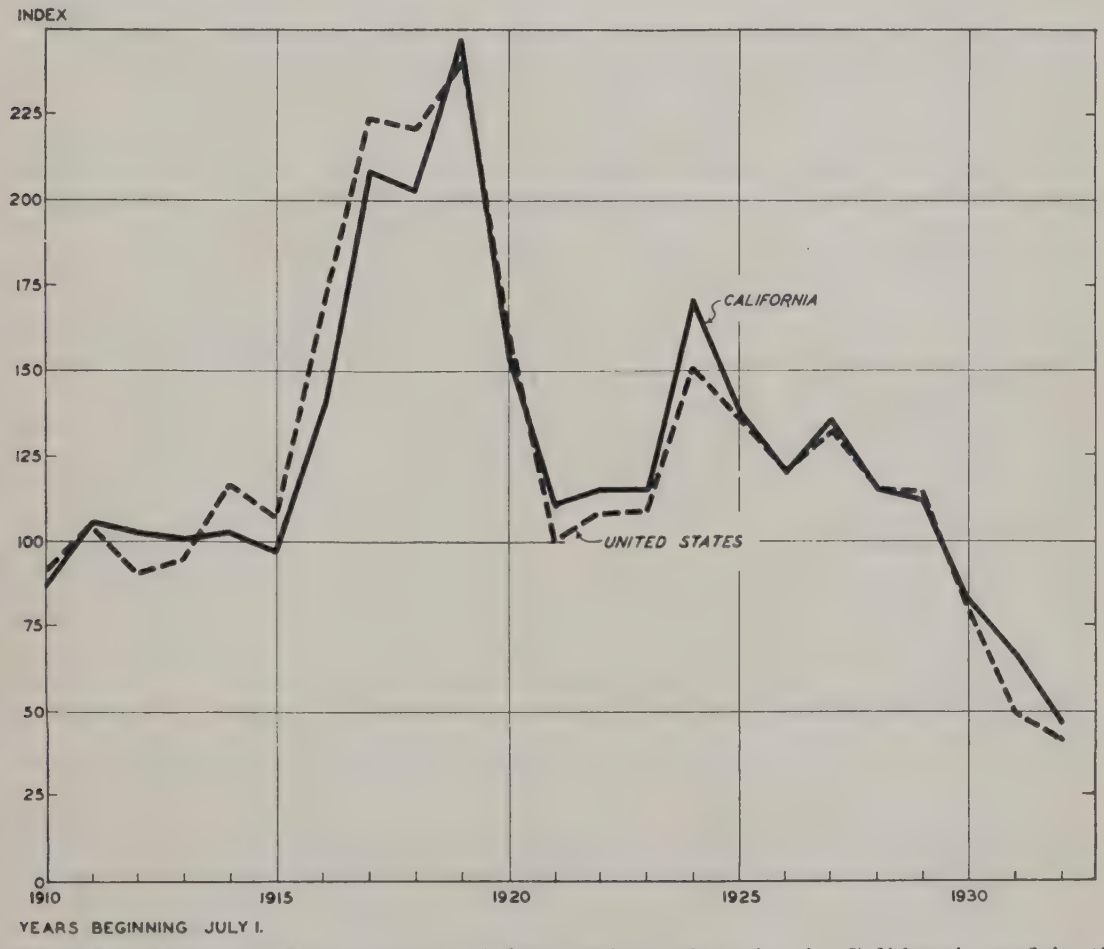


Fig. 6.—Annual index numbers of farm prices of grains in California and in the United States, years beginning July 1, 1910–1932. (July, 1910 to June, 1915 = 100.) The course of grain prices in California and in the United States during the past two decades has been very similar. (Data from tables 10 and 12.)

The farm prices of poultry products in California have been relatively lower than the farm prices of poultry products in the United States since 1918 (fig. 7). Changes in the egg industry in California, accompanied by a shift from price relations based on a production inadequate for the needs of the people of the state to price relations associated with surplus production and shipments from the state, explain the relatively low prices (low in comparison with pre-war years) of poultry products in California in recent years.

FARM PRICES IN CALIFORNIA AND IN OTHER STATES

Index numbers of farm prices for several states have been constructed in recent years. A selected group of these are presented in table 13. Each series depicts, to a varying degree, the war-time high level of prices, the price declines in 1920 and 1921, the subsequent period of approximate stability, and the recent collapse of the price structure.

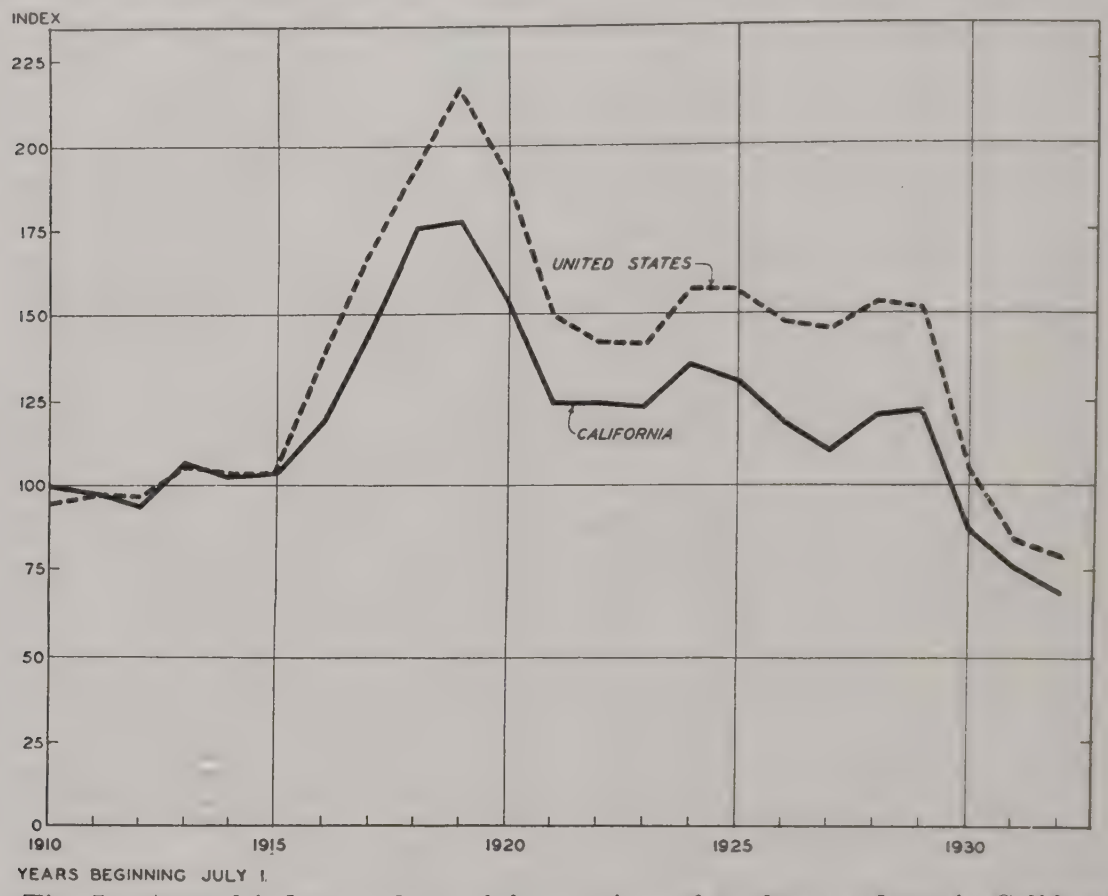


Fig. 7.—Annual index numbers of farm prices of poultry products in California and in the United States, years beginning July 1, 1910–1932. (July, 1910 to June, 1915 = 100.)

Since 1915, the farm prices of poultry products have been relatively lower in California than in the United States as a whole. This has been due to the shift of California from a deficit to a surplus-producing area for eggs. (Data from tables 10 and 12.)

A large portion of the differences between various state farm-price index numbers is accounted for by the type of products included in each index. The Alabama index, for example, is weighted heavily with cotton prices. Changes in the index, therefore, are largely reflections of changes in the price of cotton. The prices of hogs and beef cattle dominate the movements of the Iowa index, and wheat is given much weight in the North Dakota index. The importance of fruits in California explains the major differences between the index numbers for this state and those for other parts of the country.

TABLE 13

ANNUAL INDEX NUMBERS OF FARM PRICES, TWELVE SELECTED STATES, YEARS BEGINNING JULY 1, 1910–1931

(July, 1910 to June, 1915 = 100)

Year beginning July 1	New York	Pennsylvania	Ohio	Indiana	Iowa	Missouri	North Dakota	Alabama	Texas	Utah	Oregon	California
1910	98	95	93	92	91	91	103	114	110	99	101	97
1911	101	100	96	96	94	93	102	93	93	96	96	103
1912	96	98	101	100	101	102	88	100	100	98	96	97
1913	104	104	104	105	107	106	89	107	105	101	100	108
1914	99	104	106	106	106	108	117	86	92	106	108	95
1915	105	105	106	105	108	107	110	99	107	113	104	94
1916	146	142	151	144	147	147	162	145	149	154	139	126
1917	179	183	193	189	198	188	213	220	216	187	180	155
1918	199	201	209	204	218	208	220	229	224	198	198	186
1919	222	220	223	203	207	197	250	271	247	220	195	212
1920	173	178	164	146	143	147	165	160	151	154	155	186
1921	143	132	126	108	104	107	113	127	120	114	113	152
1922	135	130	131	111	114	111	107	178	160	132	122	146
1923	137	137	129	108	113	107	106	204	177	137	113	127
1924	137	145	148	134	140	131	141	179	164	150	141	145
1925	160	160	156	142	144	142	148	156	150	148	143	145
1926	151	155	148	133	139	135	139	121	118	140	130	130
1927	154	155	150	133	141	139	131	154	154	145	137	142
1928	154	154	152	139	149	146	118	156	154	150	146	134
1929	156	154	141	134	140	140	123	136	137	140	134	152
1930	123	123	111	104	108	104	75	91	89	104	87	104
1931	86	86	72	66	67	69	57	59	57	83	71	81

Sources of data:

California: Table 10.

Unweighted annual averages of the monthly index numbers of farm prices for each of the other states calculated by the author from the monthly data obtained from the following sources:

New York, Ohio, Texas, and Oregon (1910-1923): Warren, G. F., and F. A. Pearson. The agricultural situation, p. 92-94. John Wiley and Sons, New York. 1924.

Pennsylvania (1910-1922): Weaver, F. P. The prices of farm products in Pennsylvania. Pennsylvania State Col. Ext. Cir. **101**: 79. 1923.

Indiana (1910-1927): Young, E. C., and O. A. Day. Prices of farm products in Indiana. Purdue University Agr. Exp. Sta. Bul. **320**: 24. 1928.

Iowa (1910-1925): Bjorka, K. Index number of Iowa farm products prices. Iowa Agr. Exp. Sta. Current Series Report. No. **3**: 16. 1926.

Missouri (1910-1925): Cowan, D. R. G. Missouri farm prices and purchasing power. Missouri Agr. Exp. Sta. Research Bul. **84**: 34. 1926.

North Dakota (1910-1928): Fuller, O. M., and R. E. Willard. Prices of North Dakota farm products. North Dakota Agr. Exp. Sta. Bul. **232**: 51. 1929.

Alabama (1910-1925): Pope, J. D. Prices of farm products in Alabama. Alabama Ext. Ser. Cir. **91**: 75. 1926.

Utah (1910-1929): Thomas, W. P. Prices of farm products in Utah. Utah State Agr. Exp. Sta. Bul. **217**: 59. 1930.

New York (1924-1932); Pennsylvania (1923-1931); Ohio, Texas, and Oregon (1924-1931); Indiana (1928-1931); Iowa, Missouri, and Alabama (1926-1931); North Dakota (1929-1931); Utah (1930-1931): Cornell University. Farm Economics. Nos. 31-79.

Pennsylvania, Ohio, Indiana, Iowa, Missouri, North Dakota, Alabama, Texas, Utah, and Oregon (1932): Warren, G. F., and F. A. Pearson. Prices. p. 190. John Wiley and Sons, New York. 1933.

Distance from market is also a factor in an explanation of differences between state farm-price index numbers. Because distributive charges are much less flexible than the prices of commodities, they absorb an increasingly large share of the prices paid by consumers during periods of falling prices. Likewise, when prices are rising, they absorb a smaller and smaller share. As a consequence, the prices received by producers in

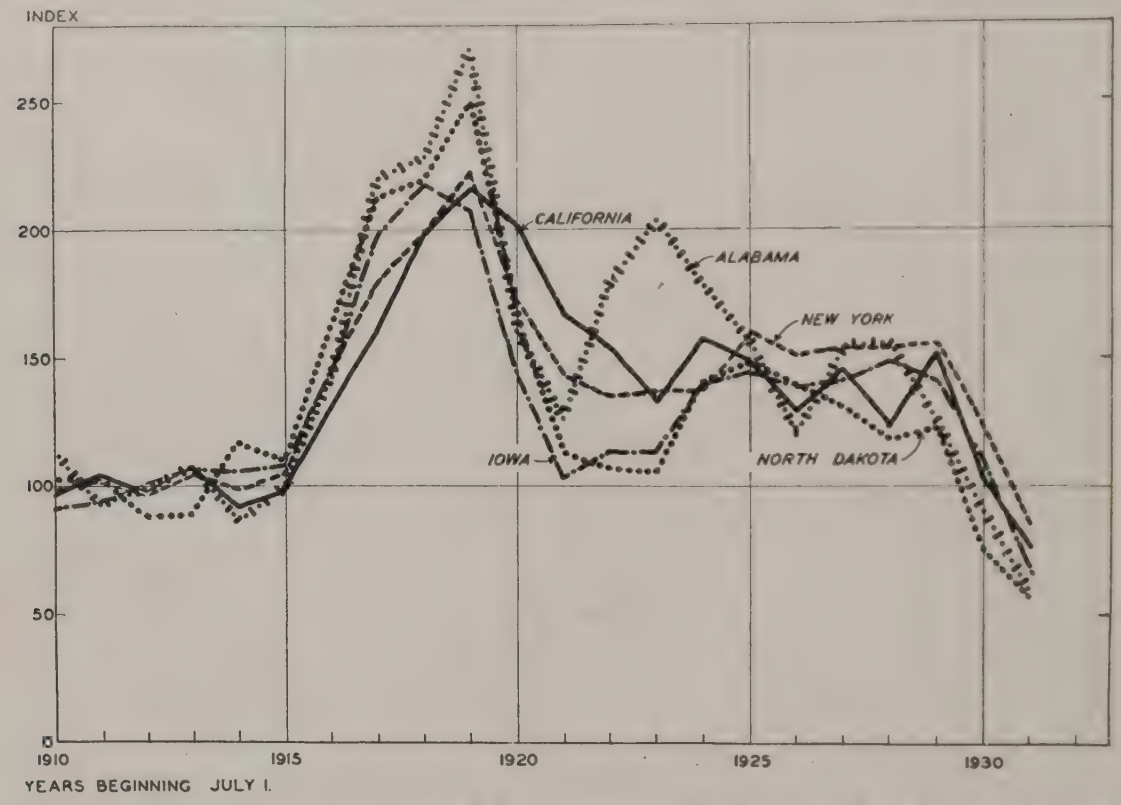


Fig. 8.—Annual index numbers of farm prices in California, New York, Alabama, Iowa, and North Dakota, years beginning July 1, 1910–1931. (July, 1910 to June, 1915 = 100.)

Farm prices in California and in New York have followed a similar course. The Alabama farm-price index was affected, to a considerable extent, by the prices of cotton; the Iowa index, by the prices of livestock; and the North Dakota index, by the prices of grains. (Data from table 13.)

areas far from the market advance relatively more during periods of rising prices, and fall relatively more during periods of falling prices, than the prices received by producers located near consuming centers.

The index of farm prices for California followed the course of the index of farm prices for New York more closely than it followed the indexes for Alabama, Iowa, or North Dakota (fig. 8). The character of the commodities produced in the first two states is more nearly the same. Relatively high cotton prices in 1922, 1923, and 1924, resulting from extensive boll-weevil damage in some of the cotton-producing areas, account for the high index of farm prices in Alabama during those years. Low grain prices in 1921, 1922, and 1923 carried the Iowa and North Dakota indexes for those years very nearly to pre-war levels.

TABLE 14

Annual Relatives of Unweighted Averages of Monthly Farm Prices, California, Years Beginning July 1, 1910–1932

(July, 1924 to June, 1929 = 100)

Year beginning July 1	Beef cattle	Veal calves	Hogs	Sheep	Lambs	Milk	Milk fat	Butter	Eggs	Chickens	Wool	Horses	Barley	Wheat	Oats	Corn	Hay	Alfalfa	Cotton*	Potatoes	Beans	Oranges	Lemons	Apples
1910	74.6	65.5	70.4	64.1	52.2	96.9	66.1	64.0	85.3	58.0	40.9	167.4	68.8	67.2	77.6	65.9	65.3	64.1	—†	69.1	70.2	—	—	59.2
1911	70.9	62.1	56.4	53.6	42.9	106.8	65.7	64.2	83.5	56.8	37.9	176.6	98.5	67.2	87.2	72.1	78.9	66.3	—	75.9	65.5	—	—	67.0
1912	78.7	68.0	60.4	57.9	47.1	96.5	74.3	67.7	79.9	54.9	44.5	162.8	85.5	69.8	86.1	71.1	98.4	78.1	—	42.6	66.5	57.5	111.8	59.9
1913	85.0	72.3	68.9	57.1	47.0	85.4	65.3	64.8	91.8	61.1	40.3	147.9	79.0	69.0	85.3	69.6	86.4	59.5	—	50.3	70.5	72.4	122.4	78.9
1914	81.8	77.5	65.9	67.6	54.3	81.6	61.8	61.3	86.7	59.1	49.6	136.5	72.1	81.1	78.1	73.5	57.0	46.5	—	53.5	69 2	52.2	83.8	57.8
1915	78 8	74.5	59.3	73.9	59.3	85.4	62.2	61.9	87.9	60.7	58.6	128.4	74.1	70.9	75.5	72.8	76.3	61.3	—	63.7	77.2	54.3	66.6	62.8
1916	90.9	80.5	81.1	94.9	76.0	88.5	77.3	71.0	101.5	68.1	92.3	128.4	119.9	111.7	112.3	102.9	100.7	88.0	—	126.4	133.7	72.4	90.0	70.5
1917	111.3	91.0	125.7	134.9	108.3	108.3	100.4	95.3	122.6	86.8	152.7	130.7	166.8	152.5	140.0	151.8	133.4	121.2	—	90.0	154.1	81.9	107.5	76.9
1918	126.8	106.9	138.9	134.1	107.4	114.0	128.1	116.3	147.4	113.2	138.6	127.3	147.7	156.3	141.9	154.9	128.2	110.9	—	98.6	118.9	120.7	126.3	128.3
1919	123.2	115.6	129.5	119.8	100.3	126.6	138.2	128.1	151.3	114.8	134.1	125.0	192.0	161.8	157.4	156.3	150.4	141.4	—	179.0	109.2	101.7	105.5	146.0
1920	101.5	97 3	101.9	84.2	75.2	119.4	110.6	110.0	127.6	112.1	56.2	118.1	116.0	130.4	123.1	107.1	132.3	104.9	—	127.7	86.8	85.1	67.0	108 6
1921	77.9	81.9	85.5	66.6	68.6	111.4	90.6	89.7	100.7	103.5	59.2	110.1	77.7	84.3	84.8	71.1	89.1	74.6	86.2	92.5	85.6	86.0	94.7	119.2
1922	81.2	81.4	84.4	92.3	93.0	107.6	104.2	95.5	102.1	93.4	109.1	110.1	85.1	84.4	99.2	78 0	95.3	89.9	120.5	68.6	86.8	80.1	104.6	110.7
1923	82 8	82 6	70.9	93.0	93.2	104.5	103.4	99.5	100.9	93.4	98.3	105.5	89.0	79.5	96.5	87.8	95.8	103.6	155.8	97.3	89.3	56.3	76.8	108.6
1924	83.2	82.5	90.9	94.9	96.2	96.9	93.4	97.2	112.2	98.4	116.4	111.2	134.6	115.6	128.8	114.3	133.9	124.0	125.1	102.7	107.9	91.0	100.3	115.0
1925	88.7	94.0	117.8	104.1	102.7	99.2	106.2	106.3	108.1	101.9	106.4	104.4	84.0	107.7	86.7	95.5	93.1	88.4	103.8	145.6	106.2	106.5	92.7	111.4
1926	90.3	96.5	112.3	94.7	97.9	100.7	98.0	97.6	95.0	101.6	85.1	100.9	76.3	96.5	78.7	89.6	83.4	82.8	75.8	102.9	85.9	87.5	59.7	79.0
1927	110.5	106.5	87.3	101.9	101.0	101.4	98.6	96.8	88.5	95.3	93.8	92.9	113.4	93.1	107.5	99.5	86.9	95.6	98.1	84.1	84.1	117.7	154.4	108.6
1928	127.3	120 5	91.7	104.4	102.3	101.8	103.8	102.2	96.2	102.7	98.3	90.6	91.8	87.0	98.2	101.1	102.7	109.3	97.1	64.7	115 9	97.3	93.0	86.0
1929	116.0	112.9	91.2	89.3	88.2	100.7	91.2	92.4	98.9	101.9	67.6	87.2	80.8	85.7	92.9	91.2	102.6	108.5	87.7	108.6	124.1	97.9	167.5	114.2
1930	84.6	91.6	79.0	55.3	58.8	86.2	64.9	70.2	68.7	85.2	47.8	74.5	57.2	58.0	65.3	73.1	74.5	73.4	53.5	73.7	75.9	91.3	90.7	45.1
1931	63.8	63.4	45.8	38.4	43.9	69.8	51.4	55.6	61.9	68.9	31.9	61.9	55.3	46.0	57.4	53.0	68.9	64.4	32.7	49.2	42.7	44.5	78.2	59.9
1932	53.2	50.7	35.0	27.1	37.7	59.1	41.4	45.1	56.0	57.6	28.6	59.6	31.9	41.0	47.5	42.2	47.5	45.7	35.3	40.9	45.7	32.6	121.7	40.2

* For relatives of cotton prices for earlier years, see table 15.

† Dashes indicate data not available.

Sources of data:

Calculations by author based on data presented in table 41.

ANNUAL RELATIVES OF THE FARM PRICES OF INDIVIDUAL PRODUCTS IN CALIFORNIA

The price relative of a product measures the percentage change in the price of that product from one time to another—from the base period to the particular time under consideration. An index number of prices, on the other hand, measures the *average* percentage change in the prices of

TABLE 15

ANNUAL RELATIVES OF ESTIMATED SEASONAL FARM PRICES, CALIFORNIA, 1910–1932
(1924–1928 = 100)

Year	Rice	Cotton*	Sugar beets	Grapes	Peaches	Pears	Apricots	Cherries	Raisins	Prunes	Walnuts	Almonds
1910	48.6	69.1	—†	42.3	57.0	77.1	51.7	61.9	92.6	105.8	63.2	67.7
1911	56.1	38.9	—	42.3	110.8	63.9	84.5	71.8	136.4	120.2	58.4	80.2
1912	68.1	64.9	—	42.3	53.8	62.0	50.0	60.6	104.4	86.5	58.4	64.1
1913	74.8	67.5	—	73.1	60.1	88.3	77.6	74.3	117.8	110.6	67.5	85.6
1914	74.8	36.3	—	50.0	47.5	75.2	63.8	84.2	122.9	110.6	69.9	83.8
1915	67.4	58.1	—	61.5	28.5	47.0	43.1	69.3	129.6	96.2	57.0	62.9
1916	58.4	103.8	71.8	80.8	66.5	101.5	79.3	84.2	159.9	125.0	65.1	82.6
1917	131.0	145.4	86.6	88.5	101.3	105.3	96.6	92.8	185.2	134.6	83.8	84.4
1918	142.2	155.7	113.3	169.2	129.7	139.1	94.8	106.4	197.0	192.3	119.7	115.6
1919	199.8	223.3	161.4	211.5	205.7	150.4	150.0	123.8	373.7	288.4	135.5	116.8
1920	90.6	155.7	149.5	330.8	218.4	189.8	139.7	138.6	441.1	211.5	94.8	84.4
1921	86.1	—	85.5	315.4	107.6	124.1	94.8	65.6	266.0	125.0	105.8	82.6
1922	82.3	—	115.5	238.5	151.9	103.4	131.0	128.7	107.7	144.2	95.8	89.2
1923	83.8	—	159.3	153.8	82.3	86.5	53.4	121.3	82.5	115.4	94.3	68.9
1924	124.2	—	104.1	130.8	113.9	139.1	87.9	73.0	101.0	105.8	107.8	86.2
1925	127.2	—	93.5	92.3	113.9	99.6	105.2	108.9	127.9	115.4	98.2	116.8
1926	98.0	—	105.4	103.8	126.6	69.5	119.0	117.6	106.1	96.2	115.9	98.8
1927	84.6	—	105.7	107.7	75.9	107.1	98.3	102.7	92.6	76.9	75.2	93.4
1928	65.9	—	91.5	65.4	69.6	84.6	89.7	97.8	72.4	105.8	103.0	104.8
1929	78.6	—	82.9	123.1	196.2	148.5	119.0	121.3	112.8	182.7	77.6	133.5
1930	62.1	—	85.0	57.7	63.3	48.9	65.5	91.6	97.6	62.5‡	87.2	62.9
1931	41.9	—	84.2	100.0	47.5	56.4	43.1	49.5	114.5	48.1‡	65.6	48.5
1932	31.4	—	74.0	46.2	25.3	20.7	34.5	37.1	60.6	52.9‡	47.9‡	49.1

* For relatives of cotton prices for later years, see table 14.
‡ Subject to revision.
† Dashes indicate data not available.
Sources of data: Calculations by the author based on data presented in table 44.

a number of products from one time (the base period) to another. A comparison of the two measures, therefore, furnishes a basis for evaluating the changes in the price of one product in terms of an average change in the prices of many products.

In a period during which the prices of practically all products are rising or falling (i.e., the levels of prices are changing), it is very difficult to appraise the status of individual prices. The price of eggs, for example, may be much lower at a certain time than it was the preceding year or during some earlier period. Perhaps, however, other prices have fallen as well, so that the decline in egg prices represents no change in

the ratio of exchange between eggs and other products. The declines in other prices may even have exceeded the declines in egg prices, in which case eggs have actually *risen* in price *relative* to other products.

The price relatives of each of the products included in the California farm-price index reflect changes in the price of that product which are due either to factors underlying general price movements or to forces acting directly on the price of the product concerned (tables 14 and 15). In the year beginning July 1, 1910, for example, the farm price of beef cattle in California was approximately 75 per cent of the average for July, 1924 to June, 1929. In 1918–19, it was 27 per cent above the level for July, 1924 to June, 1929, largely because of the influence of war-time inflation on prices generally. High prices again in 1928 and 1929 resulted from a shortage in meat supplies and were not accompanied by high prices for other products. The recent decline in beef-cattle prices was due in part to increased meat supplies. The major influence has, however, been the decline in the general price level which has carried the farm prices of practically all products to lower than pre-war levels.

A series of charts designed to facilitate a comparison of recent changes in the prices of the more important farm products in California and comparable changes in the price index for all products has been prepared (figs. 9 to 20 inclusive). In each of these charts, the five-year period, July 1, 1924 to July 1, 1929, has been used as a base.

The products whose prices in 1931–32 and 1932–33 were relatively lower than the average of all products include hogs, lambs, milk fat, wheat, barley, rice, cotton, potatoes, oranges, peaches, pears, and apricots. In both years, the prices of beef cattle, veal calves, milk, eggs, chickens, lemons, raisins, and walnuts were relatively higher than the average, when the comparison is made with the corresponding prices between July, 1924 and July, 1929.

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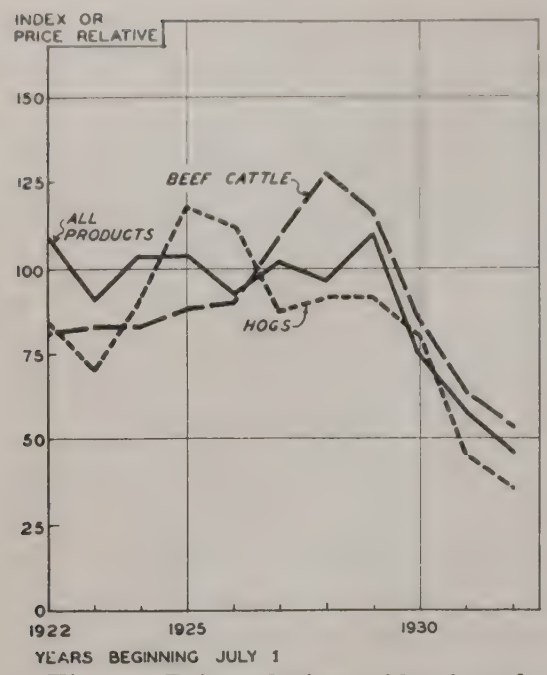


Fig. 9.—Price relatives of beef cattle and hogs and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

In 1931–32 and 1932–33 farm price of hogs was low as compared with all products. Beef cattle prices were relatively high. (Data: tables 14, 43.)

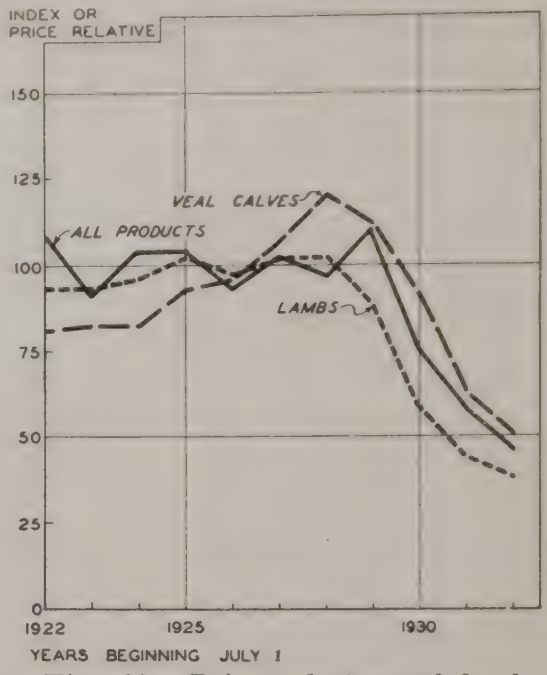


Fig. 10.—Price relatives of lambs and veal calves and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

Lamb prices have been lower and the prices of veal calves have been higher than the average of all products since 1928. (Data: tables 14, 43.)

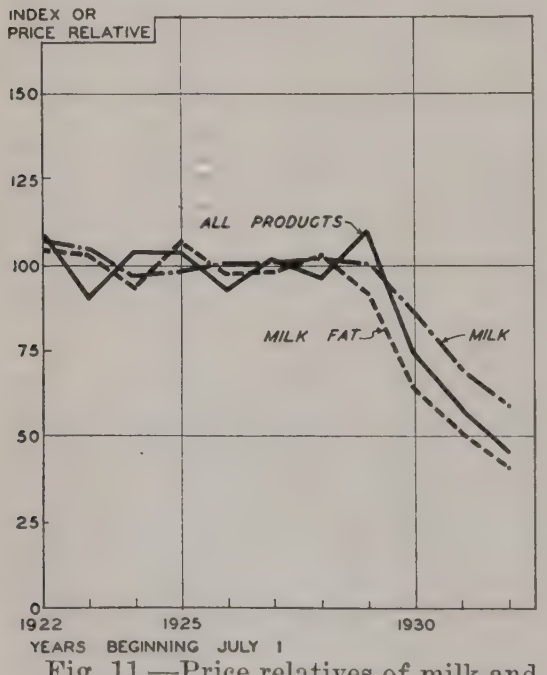


Fig. 11.—Price relatives of milk and milk fat and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

The farm price of milk fat has declined much more in the current depression than the price of milk. (Data: tables 14, 43.)

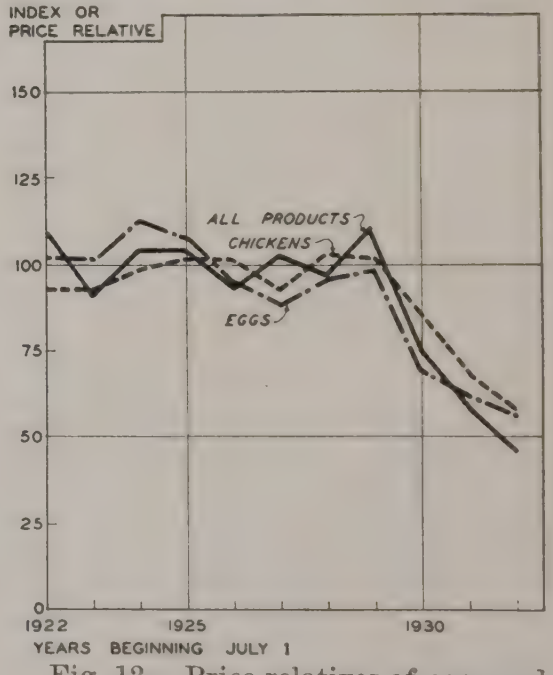


Fig. 12.—Price relatives of eggs and chickens and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

In both 1931–32 and 1932–33, chickens and eggs were higher in price than most other agricultural products in California. (Data: tables 14, 43.)

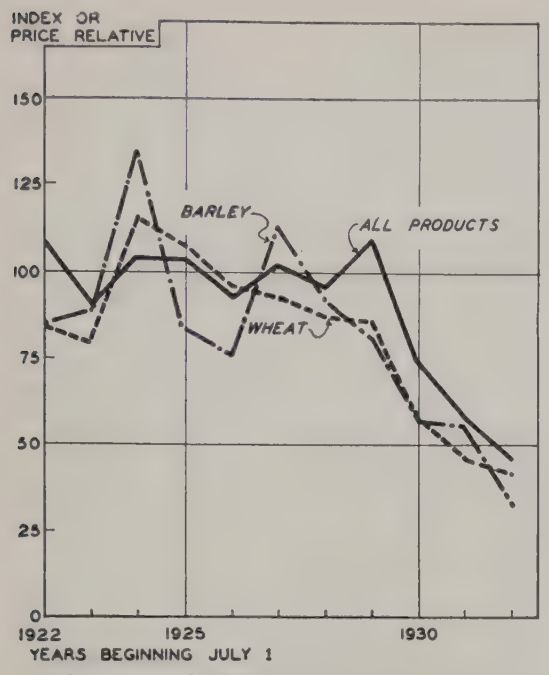


Fig. 13.—Price relatives of barley and wheat and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

The farm prices of barley and wheat in California have been low as compared with other farm prices during recent years. (Data: tables 14, 43.)

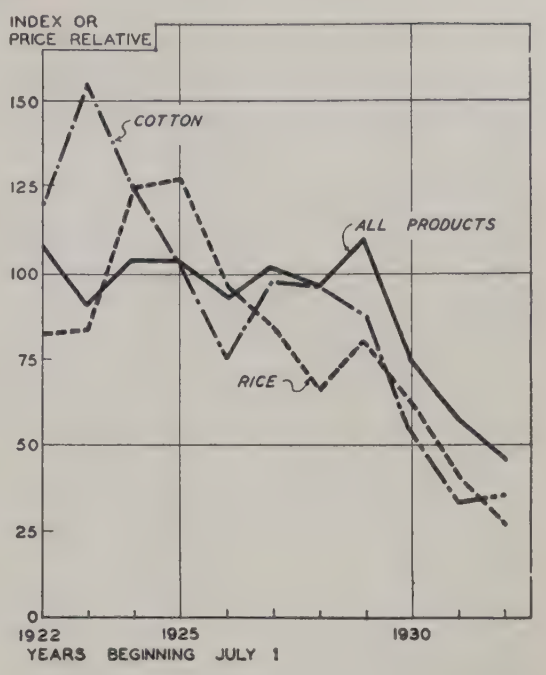


Fig. 14.—Price relatives of rice and cotton and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

In 1931–32, the farm price of cotton was one-third of the 1924–1928 average. Rice prices have also been low in recent years. (Data: tables 14, 15, 43.)

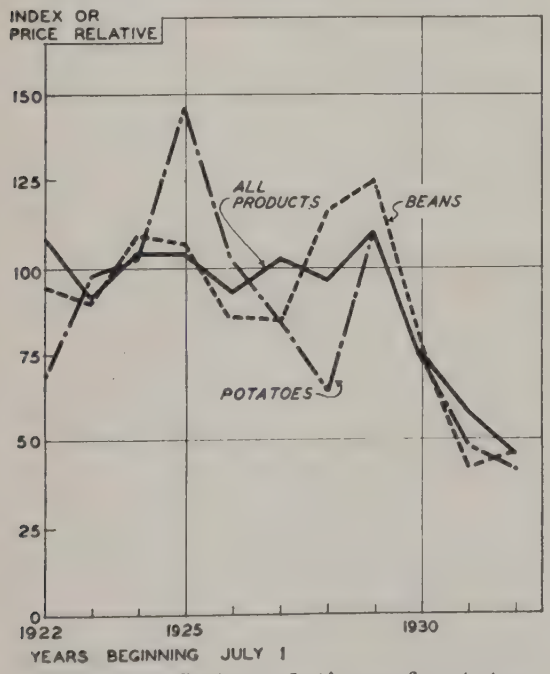


Fig. 15.—Price relatives of potatoes and beans and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

Potato prices were very high in California in 1925 and very low in 1928. Bean prices were relatively high in 1928 and 1929. (Data: tables 14, 43.)

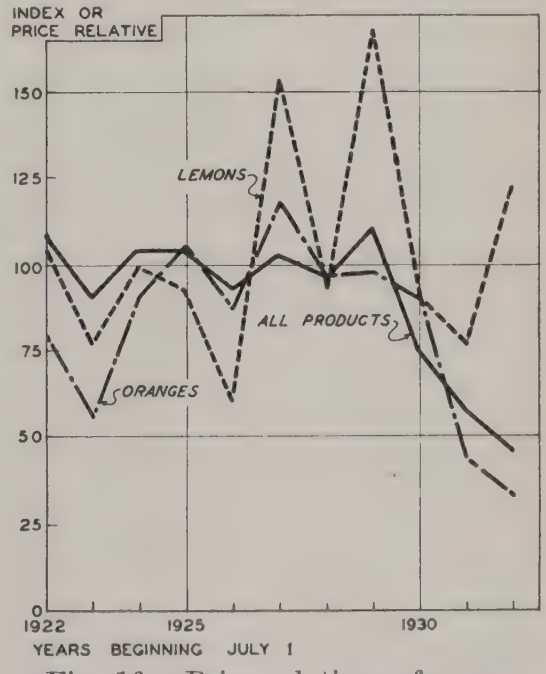


Fig. 16.—Price relatives of oranges and lemons and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

In recent years, the prices of lemons have been relatively higher than the prices of most other farm products, including oranges. (Data: tables 14, 43.)

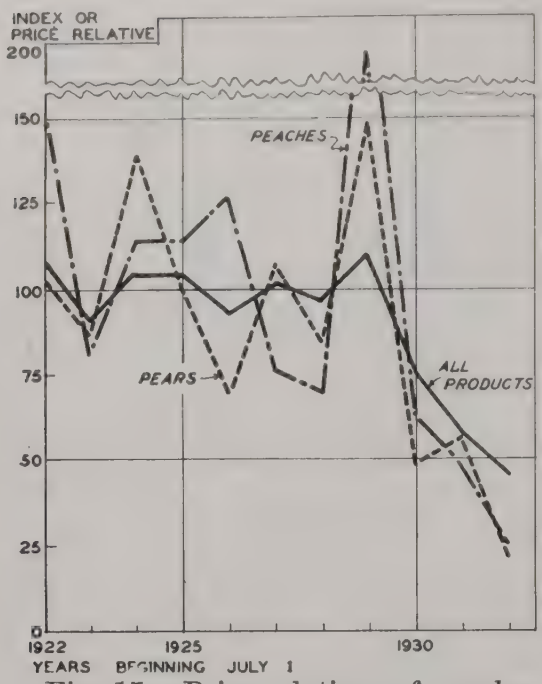


Fig. 17.—Price relatives of peaches and pears and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

The prices of peaches and pears were very high in 1929. Since then they have been below the average for all farm products. (Data: tables 15, 43.)

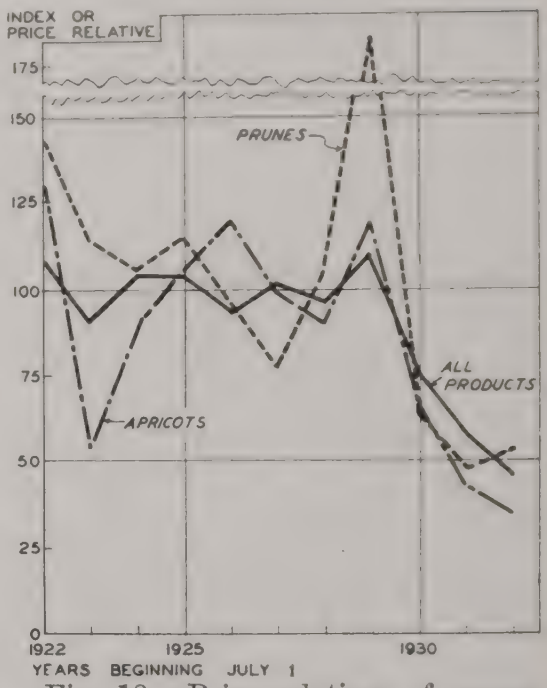


Fig. 18.—Price relatives of prunes and apricots and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

Since 1930, apricots have been relatively lower in price than most farm products. Prune prices were low in 1930 and 1931. (Data: tables 15, 43.)

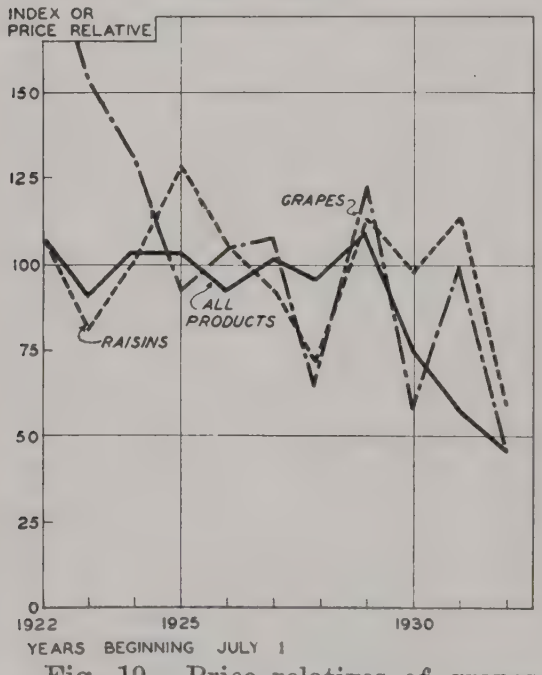


Fig. 19.—Price relatives of grapes and raisins and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

In recent years raisins have been relatively higher in price than grapes, partly because raisins were very low in the base period. (Data: tables 15, 43.)

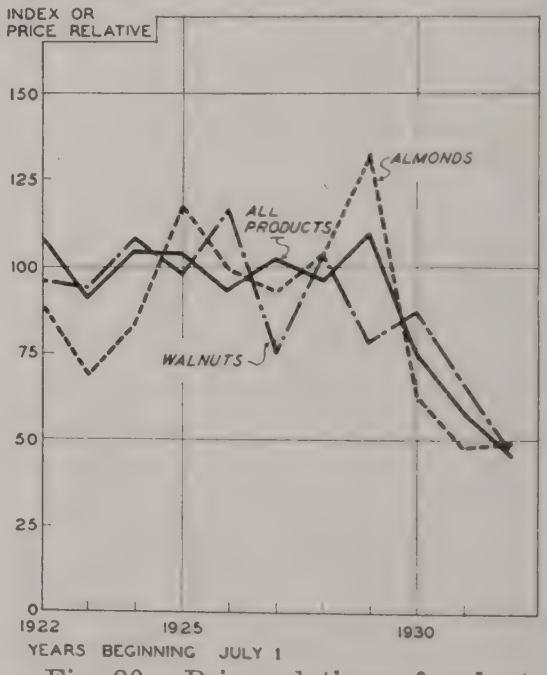


Fig. 20.—Price relatives of walnuts and almonds and index numbers of farm prices of all products, California, years beginning July 1, 1922–1932. (July, 1924 to June, 1929 = 100.)

The prices of almonds and walnuts have declined in recent years with declines in the general level of prices. (Data: tables 15, 43.)

APPENDIX A

SOURCES OF PRICE DATA

The prices of beef cattle, veal calves, hogs, sheep, lambs, milk (wholesale), milk fat (since 1929), butter, eggs, chickens, wool (unwashed), horses, wheat, barley, oats, corn, hay (loose), alfalfa hay (since 1915), cotton (since 1921), potatoes, beans (dry), oranges (since 1912), lemons (since 1912), and apples are based on the monthly prices received by producers at local farm markets in California as reported by the Division of Crop and Livestock Estimates of the United States Department of Agriculture.

Prior to September, 1923, milk prices were quoted in "cents per gallon." Since that date they have been quoted in "dollars per 100 pounds." The earlier quotations were converted to the later basis by multiplying by 9.0. This conversion factor was obtained by comparing the prices quoted on each basis with the series of prices paid to producers at country points for standard milk in the Pacific Coast states, as given in table 55 of Bulletin 514.[22] The use of the conversion factor 11.6, the approximate number of gallons in 100 pounds of milk, resulted in a series of prices which were higher than other available sources of information indicated. Moreover, the results indicated a sharp drop in milk prices at the time the shift was made in the units in which prices were quoted. No evidence could be found which supported an assumption that milk prices actually underwent a rapid change at that time. Furthermore, it is probable that milk prices quoted in small units are relatively higher than quotations in units nearly twelve times as large, owing to the influence of reports received from producers of small quantities who sell their product at approximate retail prices.

A series of monthly milk-fat prices in cents per pound for churning cream, as published in table 43 of Bulletin 514, was used to supplement the milk-fat price series for the period prior to December, 1929.

A series of the monthly prices received by producers at Modesto, California, for alfalfa was used for the years 1910 to 1914, inclusive. These prices were obtained from table 13 of Bulletin 521.[23]

A series of December 1 farm prices of cotton in California was used for the years prior to 1921. These prices were collected by the Division of Crop and Livestock Estimates of the United States Department of Agriculture.[24]

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[22] Voorhies, E. C. Dairy products. California Agr. Exp. Sta. Bul. 514:104. 1931.

[23] Braun, E. W. Alfalfa. California Agr. Exp. Sta. Bul. 521:33. 1931.

[24] U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17:148. 1927.

The prices of rice and of sugar beets are also the December 1 farm prices, as published by the Division of Crop and Livestock Estimates. Although these prices are issued as of December 1, they are sufficiently representative, for index-number purposes, of a season's average price to producers.

The prices of grapes, peaches, pears, apricots, cherries, raisins, prunes, walnuts, and almonds were compiled by the author from other available sources of information. Each price is intended to represent an average of the prices received by producers for the product throughout the marketing season. A summary of the sources of the data for each of these products follows:

Grapes: Grape prices represent, so far as can be determined from available sources of information, the average prices received by growers in California for all grapes marketed fresh.

Prices for the years 1910 to 1922, inclusive, were obtained by weighting a series of table-grape prices and a series of wine-grape prices with the estimated commercial production of these two types of grapes, as given in table 4 of Bulletin 429.[25] The series of table-grape prices was obtained by estimating the net price per ton received by growers for equal proportions of the Malaga and Tokay varieties sold on the eastern delivered auction markets. The gross auction prices were obtained from table 18 of Bulletin 429. Deductions for freight, refrigeration, packing, and loading charges were made in estimating the net prices received by growers. Wine-grape prices, for the years 1910 to 1917, inclusive, are estimates based on unpublished data compiled by S. W. Shear. An estimate of wine-grape prices in 1918 is based on estimates made by the State Board of Viticultural Commissioners and by the California Crop Reporting Service. The estimate for 1919 is based on data compiled by R. L. Nougaret[26] and on the estimate made by the California Crop Reporting Service. The estimates of wine-grape prices for the years 1920–1923, inclusive, are the estimates of the farm value per ton of wine grapes made by the California Crop Reporting Service.

From 1923 to 1931, the prices for all grapes marketed fresh represent estimates of the net price per ton received by growers for seven important varieties (Malaga, Tokay, Alicante Bouschet, Carignane, Zinfandel, Thompson Seedless, and Muscat) sold on the eastern delivered auction markets. The price for each variety was weighted with the quantity of that variety sold on these markets. The gross auction prices were ob-

[25] Shear, S. W., and H. F. Gould. Economic status of the grape industry. California Agr. Exp. Sta. Bul. 429:30. 1927.

[26] Nougaret, R. L. Status of California grape industry. California State Dept. Agr. Spec. Pub. 28:11–12. 1922.

tained from mimeographed annual summaries of the marketing seasons published by the Federal-State Market News Service. Deductions for freight, refrigeration, packing, and loading charges were made in estimating the net prices received by growers.

The prices for 1932 and 1933 were estimated by the author.

Peaches: Peach prices represent a weighted average of the prices paid by canners for peaches and of estimated prices received by growers for peaches marketed in dried form. The prices of canning peaches for the years 1910 to 1925, inclusive, are the prices of clingstones, and of freestone canning peaches given in table 26 of Ext. Cir. 1,[27] weighted with the relative production of each as given in table 17 of the same publication. The prices of canning peaches since 1925 are canning clingstone-peach prices obtained from unpublished data compiled by H. R. Wellman. The prices of peaches marketed in dried form are estimates made by the author based on the dried-peach prices presented in table 26 of Ext. Cir. 1, on the dried-peach-price quotations of packers as published in the *California Fruit News,* and on unpublished data compiled by H. R. Wellman. The weights used in combining the canning-peach prices with the prices of peaches sold in dried form were obtained from table 19 of Ext. Cir. 1. They represent the relative proportions of canned and dried peaches produced annually, expressed in equivalent fresh tons. Comparable data were obtained for later years from unpublished data compiled by H. R. Wellman.

Pears: Pear prices represent a weighted average of the approximate average price per ton paid by canners for Bartlett pears in California as given in table 24 of Bulletin 452[28] and of the estimated price per ton received for Bartlett pears marketed in fresh form based on eastern delivered auction prices as given in table 6 of the same publication. Approximate deductions for freight, refrigeration, packing, and loading charges were made in estimating the prices received by growers for fresh Bartletts. The weights used in combining the two price series represent the relative proportions of Bartlett pears sold to canners and of those shipped fresh out of the state. These proportions are based on data given in table 31 of Bulletin 452. The weight assigned to fresh Bartlett-pear prices was obtained by subtracting the fresh equivalent of dried and canned output from 89 per cent of the total commercial production—the approximate commercial production of the Bartlett variety. Data for later years were obtained from unpublished data compiled by S. W. Shear.

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[27] Wellman, H. R. Peaches. California Agr. Ext. Ser. Cir. 1:62. 1926.

[28] Shear, S. W. Economic aspects of the pear industry. California Agr. Exp. Sta. Bul. 452:90. 1928.

Apricots: Apricot prices represent a weighted average of the prices paid by canners for apricots and of the estimated prices received by growers for apricots marketed in dried form. The prices of canning apricots were obtained from table 13 of Bulletin 423.[29] The prices of apricots marketed in dried form are estimates made by the author based on the series of dried-apricot prices given in table 13 of Bulletin 423, on the dried-apricot price quotations of packers as published in the *California Fruit News,* and on unpublished data compiled by H. R Wellman. The weights used in combining the two price series were obtained from table 11 of the same publication. They represent the relative proportions of canned and dried apricots produced annually, expressed in equivalent fresh tons. Comparable data for later years were obtained from unpublished data compiled by H. R. Wellman.

Cherries: Cherry prices represent the average prices paid to growers for canning cherries (Royal Ann) as published in table 17 of Bulletin 488.[30] Prices for the years since 1929 were obtained from unpublished data compiled by H. R. Wellman.

Raisins: For the years 1910 to 1924, inclusive, raisin prices represent the weighted average prices paid to growers for the Muscat, Thompson Seedless, and Sultana varieties of raisins in the sweat box, as given in table 21 of Bulletin 429.[31] Since 1924, the prices are weighted averages of the prices of Thompson Seedless and Muscat raisins and were obtained from unpublished data compiled by S. W. Shear.

Prunes: Prune prices represent, so far as can be determined from available sources of information, the approximate average prices received by growers in California for prunes. Estimates of these prices were made by the author, with the generous assistance of S. W. Shear. These estimates are based on the quotations of packers as published in the *California Fruit News,* on the estimates of the farm value of prunes made by the California Crop Reporting Service, and on unpublished data compiled by S. W. Shear from a number of confidential sources. Although admittedly only rough approximations, owing to the wide variation in the prices obtained from different sources of information, the series of prices used in the index are considered sufficiently reliable for index-number purposes.

Walnuts: Walnut prices represent estimates of the prices received by growers for walnuts during each marketing season. Since 1922, these

[29] Wellman, H. R. Apricots. California Agr. Exp Sta. Bul. 423:41. 1927.

[30] Wellman, H. R., and E. W. Braun. Cherries. California Agr. Exp. Sta. Bul. 488: 38. 1930.

[31] Shear, S. W., and H. F. Gould. Economic status of the grape industry. California Agr. Exp. Sta. Bul. 429:105. 1927.

estimates are based on average prices paid local associations by the California Walnut Growers Association. These returns made to local associations were obtained from unpublished data compiled by H. R. Wellman. In estimating prices received by growers, deductions were made from these prices to cover the operating expenses of the local associations. Prior to 1922, the most satisfactory basis which could be found for estimating the prices received by growers for walnuts was the series of opening prices of California No. 1 Soft-Shell walnuts published in table 14 of Bulletin 475.[32] In recent years the returns made to local associations have amounted to around 5.5 per cent less than the opening price (see table 15 of above publication). By deducting this percentage from the opening prices for the years prior to 1922 and making additional deductions for the operating expenses of local associations, estimates were obtained of the prices received by growers for walnuts which are approximately comparable with the prices for later years.

Almonds: Almond prices represent the average prices paid California growers for important varieties of almonds. Since 1921, the prices are weighted averages of the prices paid growers for six varieties (Nonpareil, I X L, Ne Plus Ultra, Peerless, Drake, and Texas) and were obtained from unpublished data compiled by H. R. Wellman. Prior to 1921, the price series is based on the average prices paid to growers for four varieties of almonds (Nonpareil, I X L, Ne Plus Ultra, and Drake), as given in table 8 of Bulletin 453.[33] In order to make this series of prices approximately comparable with the data for later years, an adjustment was made, based on the relation between the two price series in the years for which both were available.

[32] Erdman, H. E., and W. U. Fuhriman. Walnut supply and price situation. California Agr. Exp. Sta. Bul. 475:46. 1929.

[33] Wellman, H. R., and E. W. Braun. Almonds. California Agr. Exp. Sta. Bul. 453:31. 1928.

APPENDIX B

SUPPLEMENTARY TABLES

TABLE 16

Monthly Farm Prices of Beef Cattle, California, 1910–1933

(Dollars per 100 pounds)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	5.30	5.30	5.80	5.70	5.20	6.00	6.00	5.00	6.00	6.00	5.00	6.00
1911	6.20	5.80	5.90	6.10	6.50	5.40	5.20	4.90	6.50	5.20	5.20	5.20
1912	5.20	5.40	6.00	6.40	5.70	5.50	5.50	5.90	5.50	5.60	5.70	6.30
1913	6.30	6.50	6.70	6.50	6.60	6.60	6.30	6.70	6.40	6.50	6.80	6.50
1914	6.70	6.90	6.80	6.80	6.60	6.60	6.50	6.40	6.60	6.50	6.40	6.60
1915	6.40	6.40	6.30	6.40	6.00	6.00	6.10	6.10	5.90	5.80	5.90	6.00
1916	6.00	6.10	6.30	6.80	6.40	6.40	6.40	6.20	6.10	6.00	6.10	6.70
1917	7.20	7.50	8.10	8.50	8.40	7.90	8.30	7.70	8.30	8.00	8.20	7.90
1918	8.30	8.80	9.30	9.80	10.10	9.50	9.40	9.20	9.00	9.10	9.10	9.50
1919	10.00	10.90	10.90	10.80	11.05	9.70	9.70	9.30	9.00	9.00	8.90	9.40
1920	10.10	10.70	10.45	10.20	9.90	8.70	8.80	8.80	8.30	8.30	8.30	8.30
1921	8.30	8.10	7.50	7.20	6.70	6.50	6.00	5.90	5.50	5.50	5.50	5.50
1922	5.80	6.20	6.70	6.90	7.00	6.50	6.20	6.20	6.20	6.20	6.30	6.40
1923	7.10	6.60	6.40	6.30	6.10	6.00	5.70	6.00	5.90	6.10	6.10	6.10
1924	6.60	7.00	7.50	7.10	6.90	6.50	6.20	6.00	6.00	5.90	5.80	6.40
1925	6.30	6.80	6.70	7.20	7.10	7.50	6.90	6.50	6.70	6.50	6.60	6.80
1926	7.40	7.30	7.30	7.30	7.20	6.50	6.50	6.60	6.70	6.90	6.70	7.00
1927	7.20	7.50	7.40	7.50	7.30	7.20	6.90	7.30	7.30	7.70	7.60	8.70
1928	9.80	9.50	9.80	9.50	9.20	9.10	9.00	9.30	10.30	10.20	10.30	9.90
1929	10.10	9.60	9.70	9.80	9.60	9.40	9.30	9.60	9.40	9.30	9.00	8.70
1930	9.00	9.10	9.00	9.10	8.50	8.60	8.00	7.00	6.70	6.60	6.60	6.60
1931	7.10	6.90	6.40	6.30	5.70	5.30	5.30	5.30	5.20	5.20	5.00	5.00
1932	4.90	4.90	4.70	5.00	4.80	4.40	4.50	4.60	4.50	4.10	4.10	4.00
1933	3.50	3.70	3.90	4.20	4.40	4.25	4.35	4.35	4.00	3.80	3.85	3.60

TABLE 17

Monthly Farm Prices of Veal Calves, California, 1910–1933

(Dollars per 100 pounds)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	5.10	5.60	6.00	6.30	5.30	7.00	6.10	5.90	6.50	6.70	6.20	6.30
1911	7.00	6.30	6.80	7.30	7.30	6.40	5.50	5.90	6.90	6.20	6.20	6.00
1912	6.00	6.30	6.60	6.80	6.20	6.20	6.10	7.20	6.30	6.40	6.40	6.90
1913	6.90	7.00	7.00	7.20	7.20	7.30	6.60	7.20	7.00	7.00	7.10	7.00
1914	7.30	7.60	7.60	7.40	7.40	7.80	7.30	7.70	8.40	7.90	7.70	8.10
1915	7.90	7.70	7.70	7.80	7.50	7.50	7.50	7.60	7.20	7.30	7.30	7.40
1916	7.60	7.40	7.50	7.70	7.60	7.50	7.50	7.50	7.50	7.40	7.70	8.20
1917	8.00	8.70	8.60	8.80	8.40	8.50	8.40	8.60	9.00	8.60	8.70	9.00
1918	8.50	8.50	10.00	10.10	10.00	10.00	9.50	10.70	11.10	9.80	10.40	10.30
1919	10.50	10.80	11.00	11.70	11.43	11.40	11.90	12.00	11.80	11.50	10.60	11.30
1920	11.00	12.60	12.00	12.00	11.70	10.70	10.90	10.20	10.20	10.20	10.20	10.00
1921	10.00	9.50	9.20	9.20	8.50	9.00	8.50	8.40	8.30	8.00	7.70	7.70
1922	7.80	8.20	8.60	8.80	8.50	8.00	7.90	8.00	8.00	8.10	8.00	8.00
1923	8.10	8.50	8.40	8.50	8.30	8.10	8.60	8.30	8.00	8.50	8.10	7.90
1924	8.50	8.40	8.80	8.50	8.20	7.50	7.40	7.50	7.80	7.60	7.50	7.50
1925	8.30	8.60	9.20	9.10	9.20	9.50	9.40	9.50	9.00	9.20	8.80	8.90
1926	9.70	9.70	9.50	10.00	9.70	9.70	9.10	9.80	9.80	9.10	9.30	9.40
1927	9.70	9.80	10.10	10.30	10.20	9.50	9.50	9.90	10.00	10.30	10.30	10.50
1928	11.10	11.10	10.80	11.40	11.30	11.30	11.50	11.80	12.00	12.20	12.10	11.90
1929	12.10	12.10	12.60	12.00	11.70	11.50	11.40	11.60	11.90	11.70	11.50	11.50
1930	11.30	11.40	11.30	11.50	10.40	10.40	10.40	10.10	9.70	9.60	9.30	9.70
1931	9.90	9.30	9.10	8.40	7.70	6.90	6.80	7.00	6.80	6.70	6.30	6.30
1932	6.20	6.20	6.30	6.40	5.80	5.50	5.40	5.60	5.20	5.10	5.00	4.85
1933	4.90	4.90	5.10	5.00	4.80	5.10	5.10	5.10	5.20	5.10	5.40	5.20

Sources of data for tables 16 and 17:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17: 144. 1927.

1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 18

Monthly Farm Prices of Hogs, California, 1910–1933
(Dollars per 100 pounds)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	7.20	8.20	8.50	9.20	8.70	8.70	8.60	8.40	8.80	8.70	8.40	7.60
1911	7.70	7.70	7.60	7.70	7.00	6.50	6.40	6.50	6.80	6.50	6.00	5.90
1912	5.80	6.20	6.20	6.50	6.50	6.50	6.60	6.70	6.60	6.60	6.60	6.60
1913	6.40	6.70	6.90	7.20	7.30	7.00	6.90	7.20	7.50	7.70	8.00	7.80
1914	7.80	7.80	8.00	8.00	7.90	8.00	8.00	8.20	8.80	7.90	7.10	7.00
1915	7.00	6.90	6.80	6.90	6.90	7.00	7.00	7.00	6.60	6.10	6.10	5.90
1916	5.70	6.10	6.90	7.60	7.40	7.30	7.00	7.20	7.40	7.40	7.60	7.90
1917	8.10	8.80	10.40	12.10	12.50	12.70	12.30	12.70	14.00	14.40	14.20	14.40
1918	14.20	14.20	14.30	14.60	14.90	14.80	15.00	15.10	15.80	16.20	15.60	14.80
1919	15.40	14.80	15.00	16.00	16.60	16.40	17.00	17.70	15.60	13.80	13.20	14.00
1920	13.80	13.75	13.50	14.10	14.10	13.60	14.00	14.10	14.00	14.00	13.10	10.50
1921	10.20	10.00	10.00	10.00	8.50	8.50	9.20	10.50	10.20	9.40	9.40	8.00
1922	8.20	9.00	10.40	10.20	10.30	10.20	10.50	11.00	10.30	10.00	10.00	9.40
1923	9.30	9.00	8.70	8.60	8.40	8.30	8.30	8.30	8.70	8.60	8.60	7.50
1924	8.00	7.70	7.50	7.50	7.40	7.20	7.00	8.70	9.00	9.50	9.50	9.40
1925	10.00	10.60	12.20	12.70	12.10	11.40	12.90	13.80	13.70	13.70	13.10	12.70
1926	12.20	12.70	13.20	13.60	13.00	13.80	14.50	14.40	13.80	13.90	13.50	12.00
1927	11.80	11.70	12.00	11.90	11.10	10.30	10.00	10.80	11.10	11.10	10.60	9.90
1928	9.40	8.90	8.70	8.50	9.10	9.10	9.70	10.70	11.70	10.70	10.20	9.00
1929	9.40	9.30	10.60	10.60	10.60	10.50	10.50	11.20	10.80	10.60	10.10	9.60
1930	9.60	10.10	10.20	10.10	9.80	10.10	10.00	9.80	10.30	10.20	9.80	9.10
1931	9.00	8.30	7.90	8.10	7.30	6.40	7.10	7.30	6.60	5.50	5.20	5.00
1932	4.60	4.40	4.40	4.40	3.70	3.40	4.40	4.50	4.20	3.95	3.75	3.50
1933	3.30	3.35	3.70	3.75	4.05	4.55	4.55	4.75	4.60	4.70	4.50	3.70

TABLE 19

Monthly Farm Prices of Sheep, California, 1910–1933
(Dollars per 100 pounds)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	4.80	4.60	6.40	4.80	5.00	5.60	5.50	5.30	5.70	5.60	4.60	4.70
1911	5.20	5.20	5.20	5.00	5.50	4.80	4.40	4.10	5.20	4.10	3.70	4.30
1912	3.80	4.20	4.50	4.60	4.70	4.50	4.20	4.60	4.60	4.20	4.60	4.80
1913	4.40	4.90	5.10	5.30	4.80	4.80	4.40	4.00	4.30	4.50	4.40	4.70
1914	4.70	4.90	4.90	5.00	4.90	4.80	4.90	5.10	5.00	5 10	5.20	5.60
1915	5.50	5.70	5.90	6.00	5.70	5.90	6.00	5.70	5.60	5.60	5.50	5.70
1916	5.80	6.10	6.10	6.60	6.40	6.60	6.50	6.30	6.30	6.50	6.60	6.70
1917	7.20	8.10	8.70	10.00	9.70	9.50	10.10	9.70	10.10	10.40	10.70	10.30
1918	10.90	10.80	11.90	12.00	12.30	11.80	10.90	11.00	11.20	11.00	11.50	11.00
1919	10.90	10.20	10.80	11.00	10.80	10.00	9.40	9.40	9.50	9.00	9.30	8.90
1920	10.30	10.80	10.40	10.80	9 80	8.80	8.00	7.70	7.50	7.20	7.00	7.00
1921	7.00	7.00	6.70	6.50	5.20	5.00	4.80	4.50	4.50	4.50	4.20	4.20
1922	4.50	5.50	7.20	7.60	6.90	6.30	6.40	7.00	7.00	7.00	7.10	7.20
1923	7.80	8.40	9.00	8 00	7.70	7.00	7.20	7.70	7.50	6.90	6.80	7.30
1924	7.90	8.00	8.60	8.00	7.50	7.00	6.50	6.60	6.90	6.80	7.20	6.90
1925	7.80	8.60	10.20	9.20	7.60	7.90	7.70	7.40	7.70	8.10	9.00	9.10
1926	9.40	9.10	8.90	8.10	8.70	8.00	7.50	7.40	7.50	7.50	7.20	7.30
1927	7.60	7.50	7.80	8.60	8.60	7.50	7.20	7.40	8.10	8.00	8.40	8.20
1928	8.60	8.00	9.00	9.00	8.40	8.00	8.10	7.80	8.00	8.60	8.30	7.80
1929	8.10	8.70	9.70	9.60	8.30	7.60	7.40	8.00	8.20	7.90	7.60	7.30
1930	7.60	7.20	7.50	7.30	5.40	5.40	5.30	4.70	5.00	4.30	5.00	4.80
1931	4.60	4.50	4.50	3.80	3.70	3.60	3.40	3.10	3.10	3.00	3.10	3.10
1932	3.20	3.40	3.40	3.00	3.00	2.50	2.00	2.40	2.20	1.80	2.35	2.20
1933	2.35	2.35	2.20	2.10	2.25	2.10	2.50	2.50	3.05	2.60	2.50	2.80

Sources of data for tables 18 and 19:
1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 145-146. 1927.
1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 20

Monthly Farm Prices of Lambs, California, 1910–1933
(Dollars per 100 pounds)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	6.10	5.50	6.50	6.00	5.70	6.80	6.80	6.10	6.50	6.70	5.50	5.50
1911	6.00	6.00	6.10	6.50	7.00	6.10	5.30	5.10	5.50	4.80	4.60	4.90
1912	4.60	5.20	5.20	5.70	5.50	5.00	5.20	5.90	5.60	4.90	5.10	5.60
1913	5.40	5.90	6.50	6.00	5.90	5.50	5.00	4.90	5.10	5.00	5.50	5.50
1914	5.90	6.10	6.30	6.40	6.00	5.50	6.20	5.90	6.00	6.00	6.10	6.50
1915	6.70	6.50	7.00	7.00	7.00	6.90	7.00	6.80	6.90	6.40	6.60	6.80
1916	6.80	6.90	7.20	8.10	7.70	7.60	7.90	7.60	7.60	7.50	7.60	7.60
1917	8.60	9.10	11.00	11.90	11.20	11.10	11.70	11.50	11.50	11.90	13.20	12.40
1918	12.70	12.80	14.10	14.30	14.50	14.50	12.90	13.20	13.60	13.00	13.00	12.30
1919	12.50	12.40	13.00	12.95	12.80	12.10	11.60	12.00	11.40	11.30	10.80	11.30
1920	12.10	13.00	12.75	14.00	12.60	10.70	10.30	9.80	9.00	9.00	9.00	9.00
1921	10.00	10.00	9.00	8.50	7.00	7.00	6.90	6.90	6.60	6.70	6.70	6.70
1922	7.00	8.50	10.30	11.50	11.00	9.30	9.40	10.00	10.00	10.50	11.00	11.50
1923	11.80	12.60	12.70	11.50	11.00	11.10	10.80	10.80	11.00	10.80	10.80	11.10
1924	11.00	11.90	12.20	11.60	11.00	10.50	10.00	9.30	9.50	10.00	10.80	11.40
1925	12.50	13.50	14.10	13.00	11.90	11.60	11.30	11.70	11.80	12.40	12.70	12.90
1926	13.60	12.80	12.40	12.00	11.60	11.50	12.00	11.80	11.50	11.80	11.40	11.50
1927	10.90	11.10	11.70	12.50	12.00	11.80	11.60	11.30	11.40	11.60	11.40	11.90
1928	12.20	12.30	13.00	13.60	13.10	12.50	12.30	11.70	11.90	11.70	11.90	11.50
1929	11.90	12.50	13.50	14.00	12.70	12.00	11.50	10.30	11.20	11.20	10.90	10.70
1930	11.30	11.40	11.20	10.30	8.30	7.90	7.80	7.40	7.30	6.90	6.90	6.70
1931	6.60	6.80	7.80	7.20	6.50	6.20	5.90	5.50	5.50	5.10	5.20	4.90
1932	5.20	5.20	6.00	5.50	4.70	4.20	4.10	4.20	4.10	4.45	4.15	4.30
1933	4.40	4.85	5.30	4.65	4.45	5.00	5.30	5.50	5.50	5.50	5.50	5.40

TABLE 21

Monthly Farm Prices of Milk (Wholesale), California, 1910–1933*
(Dollars per 100 pounds)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	2.79	2.34	1.98	1.98	2.35†	2.70	2.97	2.70	2.52	2.70	2.61	2.43
1911	2.79	1.80	2.25	2.52	2.52	2.70	3.15	2.52	2.97	2.43	2.70	2.88
1912	2.61	2.70	3.15	2.88	2.52	3.06	2.88	2.70	2.52	2.70	2.66†	2.61
1913	2.70	2.07	2.34	2.52	2.34	2.34	1.98	2.43	2.52	2.61	2.16	2.61
1914	2.11	2.07	2.07	2.07	2.07	2.21	2.16	2.30	2.34	2.21	2.30	2.30
1915	2.16	2.07	2.07	1.89	1.89	1.98	2.07	2.43	2.34	2.34	2.25	2.25
1916	2.07	2.07	2.07	2.25	2.25	2.43	2.25	2.16	2.34	2.07	2.34	2.34
1917	2.16	2.52	2.34	2.34	2.70	2.34	2.43	2.61	2.70	2.79	2.79	2.97
1918	2.79	3.33	3.06	2.97	2.79	2.88	2.79	2.70	2.88	2.97	3.15	3.06
1919	3.06	2.97	3.33	2.97	2.97	3.06	3.15	3.06	2.97	3.15	3.33	3.51
1920	3.60	3.33	3.42	3.24	3.51	3.60	3.69	3.87	3.60	3.42	3.42	3.24
1921	2.79	2.70	2.70	2.70	2.70	2.70	2.61	2.70	2.97	3.15	3.15	3.15
1922	2.97	2.97	3.06	2.79	2.70	2.88	2.88	2.70	2.70	2.88	2.79	2.97
1923	2.70†	2.70	2.79	2.79	2.88	3.06	2.97	2.88	2.82†	2.82†	2.63	2.69
1924	2.80	2.86	2.92	2.60	2.50	2.40	2.50†	2.60	2.40	2.50	2.40	2.50
1925	2.40	2.60	2.97	2.38	2.74	2.46	2.22	2.40	2.84	2.96	2.98	3.03
1926	2.57	2.44	2.74	2.32	2.63	2.06	2.72	2.71	2.58	2.68	2.20	2.90
1927	2.70	2.60	2.70	2.70	2.60	2.60	2.60	2.60	2.60	2.80	2.80	2.70
1928	2.80	2.70	2.60	2.50	2.60	2.60	2.35	2.60	2.75	2.75	2.80	2.70
1929	2.65	2.65	2.70	2.65	2.60	2.80	2.60	2.60	2.80	2.75	2.80	2.60
1930	2.65	2.65	2.65	2.45	2.55	2.55	2.35	2.40	2.45	2.30	2.40	2.40
1931	2.30	2.30	2.15	2.05	2.05	1.95	1.80	2.05	2.05	2.00	2.00	2.05
1932	1.85	1.80	1.60	1.85	1.50	1.40	1.65	1.65	1.65	1.65	1.65	1.70
1933	1.70	1.55	1.50	1.25	1.35	1.35	1.60	1.60	1.60	1.65	1.60	1.50

* Prices prior to September, 1923, were converted from gallon basis to 100 pound basis by multiplying by 9.0 (see discussion in text). Prices for 1914 were estimated by the author. †Interpolated.

Sources of data for tables 20 and 21:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17: 145-146. 1927.

Table 20: 1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

Table 21: 1926-1933: Unpublished data obtained from the U. S. Dept. Agr.

TABLE 22

Monthly Farm Prices of Milk Fat, California, 1910–1933

(Cents per pound)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	38.1	36.5	32.3	29.5	30.8	32.2	34.4	36.3	36.5	38.8	39.5	38.3
1911	36.8	34.3	28.3	24.5	25.5	25.2	25.3	28.0	29.5	33.8	35.5	38.0
1912	41.0	39.0	35.0	29.9	29.0	31.8	32.6	36.5	38.7	40.0	40.5	39.5
1913	41.5	41.0	41.0	33.0	31.3	31.9	33.9	36.5	39.5	37.2	37.8	35.7
1914	33.5	30.0	26.4	26.3	28.0	28.5	28.5	31.3	33.5	34.9	37.5	33.7
1915	31.8	31.3	27.0	26.0	27.1	29.0	30.0	31.0	31.0	31.0	32.0	31.5
1916	32.3	34.5	31.8	30.8	28.9	29.0	29.9	30.9	35.3	38.0	40.0	39.9
1917	42.7	43.0	40.0	42.5	41.3	42.1	45.6	49.8	51.1	53.1	49.8	53.8
1918	57.0	55.0	52.0	43.5	45.0	49.0	56.0	57.3	64.3	69.5	67.1	71.0
1919	65.8	60.0	66.0	62.9	65.8	65.7	64.0	65.0	72.0	74.0	75.1	75.6
1920	73.4	72.9	69.3	65.3	62.0	63.8	69.0	71.0	75.9	67.5	63.5	58.0
1921	50.0	54.0	43.2	39.1	35.9	38.6	45.5	49.3	50.2	53.5	54.0	48.0
1922	42.0	45.0	38.4	36.5	40.0	43.5	47.0	46.0	54.0	57.2	54.0	56.0
1923	56.9	53.6	50.0	48.9	50.5	53.0	50.0	54.0	56.5	57.0	58.0	57.0
1924	56.8	54.7	52.0	41.7	40.5	44.5	44.2	45.7	44.0	44.8	44.0	48.4
1925	49.5	49.3	49.0	45.8	46.7	51.5	54.4	57.0	59.5	63.5	64.0	56.0
1926	49.0	51.0	47.4	46.3	46.0	46.0	45.7	48.2	49.0	49.8	49.3	51.0
1927	52.5	52.3	50.0	47.7	46.5	48.0	48.0	47.8	51.6	53.7	53.7	53.2
1928	51.5	49.2	47.4	44.2	46.3	47.7	50.5	53.0	55.7	56.6	54.6	55.3
1929	50.9	52.2	49.4	47.7	50.0	49.8	50.1	51.3	54.4	54.0	53.5	45.9
1930	40.0	41.0	41.0	42.0	40.0	37.0	37.0	38.0	39.0	41.0	38.0	36.0
1931	27.0	28.0	30.0	26.0	26.0	25.0	25.0	28.0	30.0	32.0	32.0	31.0
1932	26.0	24.0	23.0	20.0	19.0	19.0	18.0	20.0	20.0	22.0	22.0	27.0
1933	20.0	18.0	19.0	19.0	22.0	23.0	26.0	23.0	23.0	22.0	22.0	21.0

TABLE 23

Monthly Farm Prices of Butter, California, 1910–1933

(Cents per pound)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	34	32	31	29	28	28	28	30	32	34	35	36
1911	34	32	30	27	26	26	26	27	29	30	32	34
1912	35	35	33	31	30	29	30	31	32	34	35	35
1913	34	35	34	32	30	29	30	31	34	35	36	36
1914	34	31	28	27	26	26	28	28	30	32	34	34
1915	32	30	28	26	26	26	28	29	30	30	30	32
1916	32	32	30	28	28	28	28	28	30	32	34	36
1917	36	39	38	36	36	37	40	42	44	46	47	48
1918	50	50	50	46	44	44	48	51	53	58	61	62
1919	60	56	55	55	56	57	57	56	58	62	66	66
1920	65	64	64	62	60	60	58	60	63	64	64	62
1921	54	48	46	42	38	37	38	43	46	47	48	50
1922	46	43	41	38	38	40	42	42	44	48	50	50
1923	48	47	46	44	45	46	46	46	46	49	52	50
1924	51	51	52	45	43	44	43	46	46	46	48	50
1925	49	46	46	49	46	47	52	53	55	58	62	57
1926	47	51	49	44	43	44	43	46	47	46	48	49
1927	51	48	51	46	45	44	45	44	47	50	49	52
1928	49	46	47	44	42	44	46	49	51	53	53	52
1929	49	50	49	46	44	48	48	49	49	50	49	49
1930	40	42	40	39	40	39	39	39	40	41	39	36
1931	31	29	30	28	28	26	27	29	31	33	32	33
1932	27	25	24	21	20	20	18	21	22	22	23	28
1933	21	19	20	20	23	23	25	23	22	21	23	21

Sources of data for tables 22 and 23:

Table 22: 1910-1929: Voorhies, E. C. Dairy products. California Agr. Exp. Sta. Bul. **514**: 86. 1931.

Table 23: 1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 145. 1927.

Table 22, 1930-1933 and table 23, 1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 24

Monthly Farm Prices of Eggs, California, 1910–1933

(Cents per dozen)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	38.0	30.0	23.0	21.0	22.0	24.0	25.0	28.0	32.0	37.0	42.0	41.0
1911	34.0	28.0	21.0	18.0	19.0	21.0	22.0	25.0	30.0	36 0	40.0	41 0
1912	37.0	28.0	20.0	20.0	19.0	20.0	22.0	25.0	29.0	34.0	40.0	39 0
1913	32.0	25.0	19.0	18.0	20.0	21.0	22.0	30.0	31.0	38.0	50.0	46.0
1914	43.0	29.0	18.0	20.0	20.0	25.0	25.0	30.0	34.0	40.0	44.0	41.0
1915	35.0	24.0	19.0	19.0	20.0	21.0	24.0	26.0	31.0	39.0	47.0	42.0
1916	35.0	29.0	18.0	19.0	22.0	24.0	26.0	30.0	35.0	43.0	49.0	43.0
1917	40.0	31.0	24.0	27.0	31.0	33.0	32.0	38.0	42.0	49.0	55.0	52.0
1918	53.0	42.0	33.0	32.0	34.0	35.0	41.0	42.0	53.0	58.0	70 0	72.0
1919	62.0	38.0	35.0	40.0	43.0	44.0	46.0	50.0	56.0	64.0	73.0	76.0
1920	61.0	41.0	35.0	36.0	37.0	38.0	45.0	49.0	56.0	65.0	76.0	60.0
1921	48.0	30.0	26.0	20.0	20.0	22.0	29.0	35.0	41.0	50.0	55.0	50.0
1922	29.0	28.0	22.0	22.0	23.0	24.0	27.0	27.0	38.0	50.0	54.0	52.0
1923	41.0	29.0	21.0	23.0	25.0	27.0	29.0	33.0	36.0	47.0	53.0	48.0
1924	38.0	32.0	22.0	23.0	23.0	25.0	30.0	34.0	39.0	47.0	55 0	51.0
1925	48.0	36.0	28.0	27.0	29.0	31.0	37.0	39.0	40.0	48.0	55.0	50.0
1926	38.0	28.0	24.0	24.0	26.0	29 0	31.0	33.0	37.0	44.0	47.0	44.0
1927	37.0	26.0	21.0	22.0	21.0	22.0	23.0	27.0	33.0	39.0	44 0	42 0
1928	35.0	24.0	22.0	23.0	22.0	25.0	29.0	31.0	34.0	39.0	42.0	44.0
1929	38.0	29.0	25.0	25.0	24.0	30.0	31.0	36.0	39.0	43.0	47.0	46.0
1930	39.0	27.0	24.0	23.0	23.0	23.0	23.0	25.0	32.0	34.0	35.0	27.0
1931	23.0	17.0	15.3	15.5	16.1	16.0	18.1	23.1	26.5	30.0	29.5	29.2
1932	23.4	15.8	14.2	13.3	13.7	13.7	15.4	17.0	20.9	25.4	27.4	26.0
1933	26.0	13.4	12.7	13.0	14.6	15.1	16.3	18.9	22.0	24 5	24.5	23 0

TABLE 25

Monthly Farm Prices of Chickens, California, 1910–1933

(Cents per pound)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	14.8	14.7	14.4	15.1	15.2	14.2	14.2	14.6	14.4	14.8	15.4	15.3
1911	15.0	14.9	15.2	15.4	14.9	15.0	15.0	14 8	15.1	14.8	14.6	14.9
1912	14.6	14.5	14.4	14.2	14.0	14.1	14.3	14.0	14.0	14.2	14.3	14.2
1913	13.8	13.7	13.6	13.7	14.4	14.8	14.2	14.6	15.5	17.4	15.2	15.5
1914	15.3	15.4	16.0	17.0	14.8	17.2	14.5	15.7	15.0	15.0	15.0	15.4
1915	15.4	15.0	15.4	15.8	15.4	15.2	15.1	15.6	15.7	15.2	15.3	15.2
1916	15.0	14.7	15.2	16.6	16.5	16.5	16.3	16.3	16.2	16.7	16.6	17.3
1917	17.6	17.7	18.7	19.2	18.7	18.3	18.7	17.8	20.0	20.7	22.2	22.3
1918	22.9	24.0	24.0	24.5	26.0	24.0	26.5	25.0	27.1	27.6	29.4	27.8
1919	30.7	28.0	31.0	33.0	32.0	31.5	31.0	29.0	28.0	29.0	30.0	29.0
1920	29.0	29.2	29.7	30.4	30.2	29.8	26.8	28.0	30.0	30.0	30 0	30.0
1921	30.0	29.0	29.0	29.0	27.0	27.0	26.0	25.0	28.0	26.0	28.0	27.0
1922	27.0	27.0	26.0	27.0	26.0	26.0	25.0	23.0	25.0	25.0	25.0	23.0
1923	22.8	22.4	24.0	24.0	24.3	24.0	24.0	23.0	26.0	25.0	25.1	23.0
1924	24.3	23.0	24.0	22.8	24.0	23.6	26.0	24.0	24.2	26.0	25.2	24.5
1925	24.9	24.5	26.1	26.0	25.2	26.6	25.8	26.9	27.1	26.2	27.6	26.2
1926	25.4	25.8	26.2	27.0	22.0	28.1	27.1	25.8	26.8	26.0	27.7	26.2
1927	26.0	26.3	26.1	26.3	25.4	24.0	23.4	21.8	24.7	24.5	25.4	25 4
1928	25.3	24.8	26.4	26.5	20.0	25.4	25.8	25.5	26.3	26.9	26.6	26.8
1929	27.0	27.5	27.6	27.6	23.0	26.5	26.8	27.2	28.6	26.8	27.2	26 4
1930	26.0	25.6	25.7	24.9	25.1	23.9	21.5	22.6	22.8	23.7	23.1	22.9
1931	22.2	21.1	21.0	21.6	20.6	19.5	19.0	19.0	21.0	20.0	19.3	19.0
1932	17.9	15.9	16.4	16.0	15.0	14.1	14.7	15.0	16.0	16.9	15.9	15.0
1933	15.0	14.0	13.4	14.1	14.2	13.8	13.5	14.0	13.0	13.0	13 3	13 0

Sources of data for tables 24 and 25:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17: 147. 1927.

1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 26

Monthly Farm Prices of Wool (Unwashed), California, 1910–1933
(Cents per pound)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	17.0	17.0*	17.0*	16.0*	16.0	17.0	17.0	15.0	16.0	15.0	14.0	13.0
1911	12.0	12.0	12.0	11.0	12.0	14.0	12.0	14.0	11.0	12.0	11.0	10.0
1912	13.0	12.0	13.0	14.0	14.0	15.0	16.0	15.0	15.0	14.0	16.0	15.0
1913	14.0	12.0	18.0	15.0	13.0	14.0	16.0	18.0	11.0	11.0	12.0	12.0*
1914	12.0*	11.0	12.0	14.0	15.0	17.0	15.0	16.0	15.0	14.0	13.0	17.0
1915	15.0	16.0	18.0	19.0	18.0	22.0	21.0	21.0	17.0	17.0	16.0	17.0
1916	17.0	15.0	22.0	22.0	24.0	25.0	23.0	25.0	24.0	20.0	26.0	23.0
1917	24.0	31.0	38.0	38.0	46.0	50.0	53.0	55.0	47.0	53.0	48.0	50.0*
1918	53.0	53.0	51.0*	49.0*	48.0	50.0	51.0	49.0	50.0	50.0	49.0	50.0
1919	44.0	40.0	42.0	37.0	44.0	47.0	49.0	47.0	45.0	41.0	40.0	46.0
1920	45.0*	44.0	45.0	49.0	43.0	41.0	36.0	28.0*	20.0	24.0	24.0	22.0
1921	15.0	12.0	12.0	11 0*	10.0	10 0	11.0	11.0	13.0	13.0	11.0	14.0
1922	16.0	23.0	30.0	27.0	32.0	35.0	35.0	35.0	35.0	29.0	30.0	35.0
1923	36.0*	38.0	38.0*	38.0	46.0	41.0*	36.0	30.0	32.0	35.0	30.0	30.0*
1924	30.0	30.0	35.0*	40.0	31.0	33.0	33.0	36.0	35.0	35.0	40.0	36.0
1925	41.0	43.0	44.0	44.0	40.0	37.0	40.0	40.0	37.0	35 0	34.0	39.0
1926	39.0	36.0	34.0	32.0	29.0	30.0	29.0	31.0	30.0	26.0	29.0	24.0
1927	28.0	30.0	31.0	28.0	27.0	27.0	26.0	29.0	31.0	25.0	28.0	29.0
1928	31.0	35.0	35.0	34.0	35.0	37.0	37.0	35.0	33.0	35.0	34.0	31.0
1929	35.0	32.0	33.0	30.0	29.0	28.0	27.0	28.0	24.0	25.0	26.0	23.0
1930	24.0	22.0	19.0	18.0	18.0	16.0	16.0	17.0	19.0	18.0	16.0	18.0
1931	16.0	15.0	14.0	15.0	14.0	13.0	12.0	13.0	12.0	11.0	11.0	12.0
1932	10.0	11.0	11.0	9.0	8.0	7.0	7.0	7.0	8.0	9.0	9.0	8.0
1933	7.0	8.0	8.5	10.0	15.0	17.0	20.0	20.0	20.0	21.0	21.0	20.0

TABLE 27

Monthly Farm Prices of Horses, California, 1910–1933
(Dollars per head)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	115	128	120	150	162	160	125	135	135	150	145	147
1911	150	145	135	153	160	172	150	163	150	155	160	165
1912	150	155	158	135	150	155	140	150	150	135	150	139
1913	150	135	134	145	137	136	140	133	140	120	117	136
1914	125	134	128	125	129	125	124	127	110	120	122	120
1915	118	111	117	119	125	110	110	112	120	110	112	115
1916	110	113	114	117	110	106	115	106	110	110	107	117
1917	112	108	114	115	109	115	109	116	108	115	115	107
1918	111	120	116	118	118	119	111	114	110	110	108	105
1919	113	114	108	118	102	117	110	117	120	97	93	102
1920	108	109	112	111	121	113	112	106	106	105	105	100
1921	100	100	100	100	100	100	98	98	98	95	95	95
1922	90	95	98	100	98	95	98	98	98	98	98	94
1923	85	95	100	105	95	94	93	96	97	90	95	96
1924	94	89	90	85	86	88	90	100	98	96	93	91
1925	88	101	102	105	105	97	92	102	95	85	93	95
1926	79	90	89	90	92	90	80	90	80	84	91	95
1927	85	95	90	90	85	85	75	80	79	80	84	86
1928	87	85	82	78	73	80	80	77	79	79	80	78
1929	78	83	86	81	68	81	76	81	79	79	84	81
1930	77	72	74	70	71	71	57	62	63	69	66	64
1931	69	70	70	63	64	61	65	60	57	55	52	52
1932	53	51	57	52	48	52	48	50	46	50	52	47
1933	47	51	53	58	60	56	59	56	61	56	58	62

* Interpolated.

Sources of data for tables 26 and 27:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 146. 1927.

1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 28

Monthly Farm Prices of Barley, California, 1910–1933

(Cents per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	70	70	72	71	66	61	56	54	54	52	54	52
1911	51	52	52	58	67	66	62	64	69	73	80	85
1912	86	88	90	90	88	82	74	67	66	68	68	71
1913	73	70	65	64	68	76	72	66	66	66	68	68
1914	66	62	63	61	55	55	50	44	50	54	56	58
1915	62	71	72	67	63	54	49	54	56	57	61	61
1916	62	67	66	62	62	63	64	69	76	82	90	100
1917	104	108	110	118	128	116	102	110	118	116	118	123
1918	126	144	166	171	171	156	136	130	121	116	118	115
1919	109	102	104	110	128	146	148	142	150	156	145	144
1920	160	168	168	162	160	163	156	142	124	110	102	94
1921	80	72	68	62	57	60	60	58	57	58	58	60
1922	60	59	65	72	78	70	58	57	58	62	64	75
1923	78	73	76	76	78	72	66	64	66	76	76	79
1924	72	71	75	80	65	75	98	120	120	119	122	115
1925	128	125	99	87	91	84	75	75	73	75	76	74
1926	76	65	59	62	58	48	60	58	54	53	57	55
1927	56	61	64	66	72	85	81	88	90	93	96	93
1928	97	98	97	94	89	85	77	71	68	72	76	74
1929	81	78	77	75	75	68	69	72	70	70	71	71
1930	67	64	61	61	57	52	45	46	49	48	47	45
1931	43	44	41	45	52	51	43	43	44	44	52	51
1932	51	50	47	45	40	28	23	25	25	25	27	25
1933	25	23	24	26	31	30	47	44	43	42	42	41

TABLE 29

Monthly Farm Prices of Wheat, California, 1910–1933

(Cents per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	113	114	113	109	105	100	95	98	98	94	94	93
1911	90	88	86	86	90	90	90	88	84	84	86	89
1912	90	92	94	98	102	104	104	98	91	90	92	95
1913	98	94	92	94	97	100	96	92	92	91	93	94
1914	95	96	96	95	95	96	92	90	98	103	102	107
1915	118	129	130	128	124	109	98	96	94	92	94	98
1916	102	102	98	94	96	98	96	104	115	126	142	148
1917	146	148	152	182	238	234	204	208	208	204	202	200
1918	206	214	212	216	214	212	218	216	214	208	210	215
1919	212	210	214	214	213	219	222	218	218	214	207	204
1920	212	224	228	228	235	242	242	229	218	208	190	170
1921	158	157	157	140	131	138	135	120	114	112	108	108
1922	104	106	113	117	121	124	118	106	101	105	112	119
1923	122	121	122	119	119	120	108	102	105	106	108	105
1924	108	105	115	111	110	120	130	130	135	150	163	162
1925	170	190	186	155	157	167	152	151	155	141	149	151
1926	149	155	146	145	142	131	132	129	126	125	135	133
1927	130	136	135	130	133	139	127	122	125	120	120	122
1928	125	128	128	135	144	130	122	116	114	121	121	121
1929	118	125	123	120	118	108	110	120	122	122	121	123
1930	122	119	113	114	113	106	93	93	88	85	84	82
1931	80	74	68	68	72	63	58	56	56	57	70	70
1932	69	69	67	63	63	55	49	57	59	55	54	53
1933	52	50	53	58	66	66	84	79	74	70	71	70

Sources of data for tables 28 and 29:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 137-139. 1927.

1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 30

Monthly Farm Prices of Oats, California, 1910–1933

(Cents per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	64	63	63	62	60	58	54	53	52	50	50	48
1911	46	44	44	47	51	52	50	48	50	52	56	58
1912	59	58	56	57	60	60	56	51	50	52	54	58
1913	60	58	54	52	54	56	57	58	55	55	58	58
1914	56	52	48	52	48	52	53	45	44	48	52	50
1915	48	51	50	51	52	50	47	46	46	45	48	50
1916	50	52	49	48	48	46	48	52	56	62	69	76
1917	82	81	77	84	86	82	78	79	89	93	88	90
1918	88	88	92	92	96	92	92	92	86	86	92	94
1919	90	89	90	87	93	89	90	95	95	100	98	93
1920	98	103	103	107	109	107	102	106	102	88	81	83
1921	79	71	64	56	53	52	60	58	50	51	51	56
1922	56	48	50	56	58	52	50	56	58	57	60	72
1923	73	66	63	68	72	60	54	58	58	58	59	66
1924	65	62	66	60	65	64	66	73	80	83	81	90
1925	100	105	92	81	70*	59	70	57	55	57	58	56
1926	54	55	57	52	48	41	42	43	42	43	49	55
1927	51	49	53	55	55	62	61	58	61	64	67	66
1928	72	73	79	75	75	68	58	58	60	65	63	63
1929	67	65	67	64	62	56	58	54	62	61	65	65
1930	63	59	54	58	55	53	43	42	43	46	42	45
1931	41	41	39	39	40	36	33	34	34	35	39	42
1932	40	40	38	36	36	30	25	27	30	32	30	30
1933	32	30	30	30	32	33	43	41	40	40	40	40

TABLE 31

Monthly Farm Prices of Corn, California, 1910–1933

(Cents per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	91	86	86	86	86	88	82	84	85	82	82	81
1911	80	78	78	78	84	84	82	84	84	82	86	90
1912	90	90	88	93	99	102	99	96	96	92	88	84
1913	86	86	80	78	84	87	84	84	86	86	87	86
1914	84	85	84	86	89	92	88	80	76	86	91	87
1915	90	100	104	100	99	90	90	96	91	90	90	89
1916	90	89	88	90	90	88	90	96	102	110	119	122
1917	120	134	137	144	172	182	178	174	192	205	192	190
1918	198	198	194	188	173	172	194	192	195	205	196	194
1919	180	173	185	191	201	194	186	189	188	188	180	182
1920	188	196	204	204	208	208	184	174	184	170	136	140
1921	124	94	88	89	100	107	104	92	80	74	77	74
1922	74	80	90	102	107	102	98	92	85	91	98	103
1923	106	99	94	95	100	97	89	94	100	98	102	110
1924	120	110	115	120	120	125	135	135	140	136	134*	132
1925	141*	150	152	150*	147*	145	158	135	119	118	117	120
1926	115	132	100	100	104	100	104	110	110	111	109	115
1927	110	103	100	105	119	135	126	130	135	123	112	116
1928	111	118	119	122	130	135	135	141	128	124	119	126
1929	120	115	124	126	123	120	116	120	116	121	116	115
1930	110	110	106	107	107	110	109	110	115	111	91	91
1931	87	82	77	75	71	67	76	72	65	63	66	69
1932	65	66	65	61	58	61	57	57	57	49	48	48
1933	46	49	50	53	57	56	78	67	67	60	66	61

* Interpolated.

Sources of data for tables 30 and 31:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 138-139. 1927.

1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 32

Monthly Farm Prices of Hay (Loose), California, 1910–1933
(Dollars per ton)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	11.30	10.85	10.70	10.75	10.40	9.40	9.20	8.95	8.50	8.75	9.30	9.55
1911	10.00	10.40	9.90	9.50	9.25	9.15	8.90	8.35	9.00	9.35	9.90	11.30
1912	12.45	13.70	14.10	13.50	12.90	12.45	12.15	12.35	12.85	13.75	14.00	14.75
1913	15.50	15.00	14.40	14.95	15.10	14.50	14.60	13.90	13.20	13.30	13.50	13.40
1914	13.70	12.80	11.25	10.75	9.65	8.65	8.30	7.65	7.35	7.60	7.95	8.25
1915	8.50	8.35	8.40	8.65	8.60	8.60	8.25	8.50	9.05	9.90	10.95	11.85
1916	11.95	12.45	12.80	11.90	11.95	11.80	11.70	12.00	12.30	12.50	12.50	12.90
1917	13.60	15.25	17.15	18.65	18.50	16.35	15.35	15.60	16.70	17.60	18.35	19.90
1918	22.75	23.80	21.90	20.40	19.00	18.30	18.60	19.45	19.90	19.65	19.75	20.00
1919	19.05	18.30	18.20	17.45	15.65	14.65	15.25	15.25	16.00	17.00	17.10	19.20
1920	23.10	27.15	30.00	29.15	25.55	24.10	24.25	23.15	22.20	21.80	20.85	20.00
1921	19.60	18.40	16.90	14.85	13.20	12.50	11.90	11.20	10.20	10.95	11.60	12.25
1922	13.75	14.75	15.20	15.10	14.05	12.45	12.25	12.05	12.35	13.25	14.25	14.90
1923	14.75	14.15	14.10	14.80	14.25	12.90	12.20	12.65	13.10	13.50	14.00	12.00
1924	14.00	13.90	14.00	15.00	15.00	15.50	16.00	18.20	17.50	18.50	21.00	20.50
1925	20.00	19.00	19.30	23.00	20.00	17.40	15.30	13.00	12.90	11.30	14.00	14.10
1926	15.00	14.10	14.20	13.00	11.70	11.60	10.60	10.70	12.00	11.80	12.50	13.00
1927	12.50	13.50	13.00	12.50	11.50	10.00	10.50	9.90	11.00	12.00	12.40	12.30
1928	14.50	13.00	13.20	13.50	13.80	13.50	12.70	13.30	12.90	12.90	13.30	14.50
1929	15.10	16.20	17.20	17.20	16.30	15.20	14.30	13.50	14.30	14.80	14.90	15.90
1930	16.80	16.50	15.60	14.50	13.50	12.00	11.50	10.50	10.50	11.50	11.50	11.30
1931	11.30	10.20	10.30	10.00	10.00	9.50	9.20	9.20	9.50	9.10	10.80	11.00
1932	11.00	11.20	12.40	10.00	8.60	6.70	6.40	5.80	6.50	6.30	7.00	7.10
1933	7.80	6.90	7.50	7.30	6.70	6.60	6.90	7.70	7.50	7.70	8.40	9.00

TABLE 33

Monthly Farm Prices of Alfalfa Hay, California, 1910–1933
(Dollars per ton)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	9.00	9.00	9.00	8.00	8.00	8.00	8.00	9.00	10.00	10.00	10.00	10.00
1911	9.75	10.00	10.50	11.00	11.00	9.00	9.00	8.25	8.00	8.00	9.00	10.75
1912	12.00	11.00	13.00	12.25	11.00	10.00	10.25	10.75	11.00	11.00	11.00	11.50
1913	12.75	12.50	12.75	14.00	14.00	12.50	12.00	11.25	10.25	10.50	11.00	11.00
1914	9.25	8.00	7.25	6.50	6.50	6.25	6.00	6.00	6.00	6.00	6.00	6.25
1915	8.20	8.50	9.00	8.30	8.40	7.00	7.00	8.00	8.20	8.20	10.00	11.00
1916	10.20	10.50	11.20	10.00	8.20	10.60	10.90	11.40	11.40	10.80	11.90	12.70
1917	13.00	15.00	17.20	20.20	13.90	14.00	15.50	14.80	15.40	16.60	17.60	19.90
1918	22.00	24.70	23.20	20.30	16.20	17.20	17.60	18.50	19.30	18.00	17.70	17.40
1919	15.00	18.75	17.30	15.00	14.70	15.30	15.40	16.70	18.60	18.00	19.60	20.60
1920	25.50	27.10	30.20	26.00	21.10	22.00	23.40	21.10	20.00	20.00	20.00	19.00
1921	17.00	13.00	13.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	10.00	12.50
1922	13.00	14.00	14.00	16.00	12.00	10.00	10.00	10.00	11.00	13.00	15.00	15.00
1923	15.20	16.70	16.00	15.00	15.00	14.00	13.20	12.00	14.70	14.00	14.30	15.50
1924	16.40	18.00	18.00	18.50	18.50	18.00	17.80	19.00	18.00	19.00	19.50	20.70
1925	20.20	20.50	21.60	19.50	19.10	13.80	14.50	13.10	11.30	12.40	14.00	13.90
1926	14.20	16.80	14.40	13.80	11.90	12.60	11.50	11.00	12.10	12.60	13.50	13.30
1927	13.50	13.70	14.50	13.50	12.00	11.50	11.50	12.50	13.20	13.00	14.50	16.00
1928	15.70	15.60	18.00	16.70	15.90	13.70	13.70	14.00	14.00	14.60	15.50	16.40
1929	17.50	19.00	20.00	21.10	19.00	16.70	15.10	15.60	16.10	17.10	17.20	19.00
1930	20.00	19.00	18.00	16.50	14.50	12.00	11.20	10.70	11.30	11.80	12.30	12.20
1931	11.90	11.90	11.40	10.50	10.20	9.90	9.40	9.20	8.60	9.10	10.80	11.20
1932	10.80	11.50	12.50	11.00	7.80	6.90	6.00	6.00	6.60	6.80	7.40	7.90
1933	8.40	7.50	7.30	7.00	6.90	6.50	6.80	7.20	7.50	7.60	8.20	9.00

Sources of data for tables 32 and 33:

1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

Table 32: 1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 143. 1927.

Table 33: January-March, 1910: Estimates made by the author. April, 1910 to December, 1914: Braun, E. W. Alfalfa. California Agr. Exp. Sta. Bul. **521**: 33. Table 13. 1931. 1915-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. **17**: 144. 1927.

TABLE 34

Monthly Farm Prices of Cotton, California, 1921–1933
(Cents per pound)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1921	—*	—	—	—	—	—	—	10.1	14.1	18.5	18.0	17.0
1922	20.0	18.2	19.5	18.8	17.2	18.0	18.0	19.3†	20.6†	22.0	22.0	22.0
1923	24.0	24.5	25.5	26.3	26.8	27.5	26.0	27.0†	28.0	29.0	30.0	36.0
1924	36.0	31.0	30.0	30.0	29.0	27.5†	26.0†	24.5†	23.0	23.0	24.0	24.0
1925	24.3	24.6	24.2	24.0†	23.8†	23.6†	23.4†	23.1†	22.9†	22.7	22.0	21.5
1926	19.2	18.7	17.4	17.3	16.0	16.4	16.0	18.0	18.5	14.0	13.9	13.0
1927	11.5	12.9	12.8	13.5	15.5	16.0	16.0	16.0	23.0	22.8	21.0	19.7
1928	19.4	16.3	17.0	18.4	18.4†	18.4	18.4	18.4†	18.3	19.0	19.4	19.0
1929	18.5	18.4	18.9	19.0	19.0	18.5	18.5	18.2	18.6	18.8	17.6	17.6
1930	17.1	16.4	15.2	15.2	15.2	14.2	13.2	12.7	10.9	10.4	10.4	9.1
1931	8.8	9.6	10.4	9.6	9.6	8.5	9.1	6.9	6.7	5.9	6.7	5.9
1932	6.2	6.0	5.8	5.9	5.4	5.0	5.5	6.5	7.5	6.7	6.5	6.4
1933	6.4	5.9	6.1	6.5	8.5	8.8	11.0	9.0	9.2	9.3	10.3	10.6

* Dashes indicate data not available. † Interpolated.

Sources of data:
1921-1925: Unpublished data obtained from the United States Department of Agriculture.
1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 35

Monthly Farm Prices of Potatoes, California, 1910–1933
(Cents per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	77	77	74	71	75	75	72	74	75	76	80	86
1911	85	104	114	122	133	138	128	108	96	88	88	96
1912	98	98	110	129	130	104	82	68	66	67	64	61
1913	56	54	50	44	44	58	64	62	72	74	69	71
1914	71	80	82	69	62	68	68	68	64	56	65	68
1915	72	75	75	90	104	93	76	64	57	66	74	75
1916	82	108	122	114	116	114	124	131	118	113	126	144
1917	150	202	245	260	278	228	154	139	148	148	150	130
1918	110	112	105	86	94	134	178	180	145	132	126	109
1919	114	132	126	128	126	156	182	156	148	152	155	186
1920	219	254	302	416	438	393	376	307	222	192	181	135
1921	110	106	114	124	138	136	123	119	129	146	142	140
1922	140	132	130	120	109	120	118	115	108	99	91	71
1923	76	73	80	101	104	115	105	106	128	130	134	132
1924	146	130	140	160	150	170	145	127	120	130	125	105
1925	160	130	133	154	200	193	233	154	167	153	221	197
1926	206	230	210	270	250	150	130	100	110	115	130	140
1927	140	145	150	150	165	250	190	140	110	105	90	85
1928	95	100	110	145	140	100	90	85	90	85	85	90
1929	85	80	75	85	100	135	130	120	145	150	150	150
1930	155	155	155	165	195	150	140	120	115	115	120	105
1931	100	85	75	85	100	75	65	65	65	75	65	70
1932	72	70	69	65	80	65	55	50	55	50	46	50
1933	55	50	55	65	90	65	105	105	95	80	75	60

Sources of data:
1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17: 142. 1927.
1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 36

MONTHLY FARM PRICES OF BEANS (DRY), CALIFORNIA, 1910–1933
(Dollars per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	2.52	2.50	1.87	2.45	2.32	2.89	2.70	2.87	2.84*	2.80	2.65	2.61
1911	2.89	3.06	3.12	2.90	2.85	2.63	2.40	2.48*	2.56	2.48	2.43	3.35
1912	2.80	2.70	2.57	2.54	2.40	3.00	2.60	2.50	2.45	2.50	2.50	3.11
1913	2.80	2.50	2.70	2.77	2.80	2.97	3.00	2.80	2.96	3.20	2.93	2.60
1914	3.00	2.55	2.40	2.50	3.30	2.90	2.90	3.00	2.50	2.40	2.50	2.60
1915	2.60	3.00	3.00	3.00	3.19	2.78	2.91	2.77	2.50	2.80	3.72	3.14
1916	3.37	3.21	3.13	3.03	3.50	3.25	5.28	3.76	3.64	3.50	4.50	5.25
1917	4.80	5.50	5.00	6.50	8.50	8.50	7.50	6.60	6.20	6.55	6.20	6.00
1918	5.80	6.20	5.40	6.30	6.10	5.65	5.50	5.60	5.60	5.30	5.40	4.10
1919	4.60	4.70	4.25	3.90	4.10	4.40	4.10	4.00	4.20	4.20	4.50	4.50
1920	5.30	4.60	4.50	4.50	4.10	4.30	4.30	3.90	3.75	3.60	3.60	3.10
1921	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.15	3.30	3.00	3.00	3.00
1922	3.10	3.10	4.10	4.00	4.20	4.20	3.90	3.30	3.15	3.30	3.30	3.45
1923	3.60	3.90	3.60	3.80	3.55	3.20	3.30	2.98	3.96	4.15	4.00	3.20
1924	3.50	3.70	3.50	3.55	3.60	3.70	3.50	4.00	4.10	4.30	4.35	4.80
1925	4.80	4.80	4.00	4.00	4.20	5.30	4.60	4.80	5.10	4.30	4.00	4.28
1926	3.75	4.38	4.08	4.20	4.08	3.78	3.60	4.14	3.48	3.60	3.24	3.60
1927	3.60	3.42	3.12	3.24	3.12	3.42	3.48	3.72	3.24	3.00	2.91	2.91
1928	2.91	3.06	3.54	3.81	3.90	4.20	4.20	4.20	3.57	4.05	4.20	4.56
1929	4.98	5.40	5.22	5.19	5.40	5.10	5.61	5.58	5.04	5.13	4.95	4.65
1930	4.68	4.44	4.89	4.89	5.25	4.95	5.01	4.50	3.96	3.48	2.91	2.67
1931	2.37	2.64	2.52	2.19	2.25	2.25	1.95	2.07	1.89	1.86	1.92	1.98
1932	1.86	1.53	1.44	1.44	1.38	1.32	1.41	1.83	2.01	1.86	1.71	1.65
1933	1.62	1.59*	1.56	1.92	2.49	2.46	2.49	2.52	2.37	2.04	2.10	1.98

TABLE 37

MONTHLY FARM PRICES OF ORANGES, CALIFORNIA, 1912–1933
(Dollars per box)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912	1.56*	1.50*	1.82	2.04	2.00	1.84	1.76	1.78	1.76	1.84	1.56*	1.55*
1913	1.33*	1.57*	2.21	2.67	2.64	2.56	3.66	4.23	3.50	3.16	3.19	2.30*
1914	1.41*	1.43*	1.74	1.58	1.61	1.48	1.67	2.04	2.22	2.19	2.04	1.82
1915	1.44	1.34	1.48	1.48	1.70	1.74	1.52	1.65	1.88	2.25	2.55	2.01
1916	1.55	1.74	1.55	1.49	1.78	2.04	2.75	3.18	3.24	3.36	3.00	2.16
1917	1.71	1.84	2.06	2.02	1.93	2.00	2.11	2.32	2.50	2.28	2.36	2.49
1918	2.62	3.50	3.50	3.42	3.24	2.74	3.93	4.72	4.10	6.14	7.02	4.58
1919	3.58	3.12	2.98	2.98	2.88	2.80	2.80	3.00	3.00	3.00	2.75	2.76
1920	3.30	3.78	4.15	4.08	4.14	4.40	4.00	3.94	4.24	4.24	3.52	2.64
1921	2.40	1.74	1.91	2.18	1.65	1.94	2.37	2.32	2.25	2.93	2.98	2.28
1922	2.15	2.38	3.00	3.49	4.18	4.48	4.77	4.77	3.71	2.86	2.28	2.00
1923	1.91	1.96	1.90	2.14	2.06	2.10	2.21	1.81	2.14	2.58	2.86	2.02
1924	1.04	1.46	1.22	1.89	1.07	2.47	1.71	2.83	3.16	3.24	3.56	1.99
1925	2.76	2.52	3.05	3.33	3.95	4.76	4.07	3.97	4.83	5.42	6.69	2.67
1926	2.19	2.57	2.58	3.61	2.28	2.19	2.72	2.27	3.01	4.45	4.35	3.01
1927	2.54	2.93	2.56	2.57	2.20	2.83	3.09	3.79	4.23	5.08	4.65	3.58
1928	2.81	3.53	3.57	3.79	5.06	4.49	5.30	4.98	5.84	5.35	4.32	2.53
1929	2.71	2.02	1.43	1.51	1.38	2.05	1.57	2.46	2.17	2.58	2.05	3.59
1930	3.48	3.34	3.76	4.17	5.33	5.10	5.17	5.22	5.14	6.88	3.92	1.85
1931	1.45	1.28	1.51	1.25	1.92	1.37	2.12	1.64	1.55	2.37	1.71	1.39
1932	0.86	1.53	1.14	1.18	1.40	1.09	1.51	0.92	1.32	1.32	1.39	1.47
1933	1.14	0.90	0.68	0.66	0.80	1.04	1.21	1.20	1.45	1.45	1.20*	0.96

* Interpolated.

Sources of data for tables 36 and 37:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17: 141-143. 1927.

1926-1933: Unpublished data obtained from the United States Department of Agriculture.

TABLE 38

Monthly Farm Prices of Lemons, California, 1912–1933

(Dollars per box)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1912	2.92*	2.68*	2.47	2.88	2.80	2.84	2.74	2.62	2.84	2.99	3.03*	2.67*
1913	3.99*	4.09*	3.54	4.46	4.06	3.69	5.07	6.16	5.68	5.28	4.88	2.85*
1914	2.24*	2.36*	2.36	2.60	2.62	2.46	2.82	3.98	4.04	3.27	2.78	2.30
1915	1.88	1.83	1.97	1.70	1.82	2.05	1.70	1.72	1.98	2.10	2.40	2.30
1916	2.06	2.00	1.89	1.94	1.97	2.13	3.15	4.52	4.18	3.40	3.10	2.26
1917	1.78	1.82	2.20	2.16	1.86	2.30	2.71	2.75	3.25	3.24	3.12	3.04
1918	3.08	4.05	3.75	3.02	3.37	3.70	4.86	6.00	5.47	4.63	4.31	3.58
1919	3.32	3.15	2.36	2.36	2.75	3.12	2.88	2.50	2.50	3.00	3.45	2.93
1920	3.80	4.14	3.93	3.18	2.88	3.18	2.89	2.57	2.32	2.42	2.28	2.30
1921	1.39	1.22	1.33	2.38	1.80	1.50	3.58	4.75	3.88	2.97	2.07	1.48
1922	1.55	2.54	2.98	2.42	3.13	3.12	2.14	2.58	3.24	3.27	3.29	3.24
1923	2.92	3.14	3.32	2.82	3.02	5.01	5.50	4.62	4.38	3.25	1.93	1.15
1924	0.87	0.95	1.20	1.60	1.74	0.80	0.59	2.69	4.02	2.26	3.75	2.85
1925	2.60	2.45	2.66	2.51	3.53	6.60	3.92	1.56	6.08	4.73	1.94	2.09
1926	1.69	1.76	2.84	1.96	3.04	2.07	2.20	1.81	1.22	2.15	1.56	1.56
1927	2.04	1.13	1.77	1.60	1.77	2.86	4.44	3.91	8.44	6.78	4.82	3.77
1928	5.18	3.94	2.84	3.06	5.04	3.89	4.33	3.74	3.23	2.53	2.50	3.23
1929	3.60	1.74	1.97	2.09	1.57	3.37	2.72	5.27	9.41	8.53	5.92	6.84
1930	3.44	3.35	2.47	3.38	5.46	4.11	3.72	6.17	3.36	2.11	2.12	2.04
1931	2.65	1.92	2.24	1.82	2.01	2.87	3.61	4.38	3.69	3.60	1.65	1.72
1932	1.73	1.54	1.67	1.16	1.70	2.04	2.24	4.28	6.36	6.36	6.81	3.89
1933	3.08	1.40	1.78	1.79	2.11	4.16	2.14	2.33	2.36	2.52	2.28*	2.04

TABLE 39

Monthly Farm Prices of Apples, California, 1910–1933

(Dollars per bushel)

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1910	0.86	0.72	0.89	0.77	2.00	1.27	1.00	0.69	0.85	0.82	0.90	0.75
1911	0.96	0.95	0.75	0.97	0.85	0.65	0.90	0.90	0.81	0.80	0.90	0.93
1912	0.85	0.95	1 23	1.18	1.24	0.72	1.02	0.85	0.70	0.75	0.80	1.01
1913	0.90	0.65	0.74	0.84	0.92	0.97	0.90	0.90	1.00	1.00	1.05	1.30
1914	1.05	1.10	1.50	1.15	1.40	1.15	0.89	0.80	0.65	0.70	0.72	0.80
1915	0.90	0.88	0.75	0.80	0.90	1 05	0.75	0.74	0.60	0.73	0.95	0.92
1916	1.00	1.00	0.95	0.96	1.20	0.90	0.95	0.77	0.85	0.90	0.85	0.90
1917	0.95	0.96	1.10	1.35	1.25*	1.15*	1.05*	0.95	0.90	1.00	1.00	1.20
1918	1.00	1.25	1.20	1.40	1.00	1.10	1.40	1.30	1.15	1.35	1.40	1.50
1919	1.75	2.00	2.50	2.20	3.00	2.25*	1.50	1.90	1.50	1.60	1.60	2.00
1920	2.00	2.20	2.10	2.40	3.30	2.70	2.00	1.90	1.50	1.50	1.50	1.50
1921	1.30	1.35	1.50	1.50	1.46*	1.43*	1.40	1.50	1.50	1.50	1.50	1.40
1922	1.40	1.70	2.05	2.35	2.12*	1.88*	1.64*	1.40	1.25	1.40	1.35	1.10
1923	1.58	1.75	1.44	1.91	1.99	2.00*	2.00	1.31	1.12	1.42	1.00	1.29
1924	1.20	1.50	1.70	1.65	2.00*	2.30	1.10	1.40	1.50	1.57	1.50	1.35
1925	1.60	1.70	1.70	1.70*	2.10*	2.30	2.20	1.65	1.46	1.27	1.20	1.20
1926	1.30	1.40	1.40	1.40	1.95*	2.50	1.30	1.15	0.90	0.80	0.95	1.10
1927	1.05	0.95	1.10	1.15*	1.20	1.85	1.30	1.70	1.30	1.30	1.30	1.45
1928	1.60	1.80	1.80*	1.80*	1.65*	1.50	1.20	1.05	1.00	1.00	1.10	1.20
1929	1.15	1.25	1.32*	1.40*	1.48*	1.55	1.55	1.40	1.40	1.65	1.30	1.50
1930	1.50	1.75	1.80	1.80	1.90	1.90	0.85	0.25	0.90	0.70	0.50	0.55
1931	0.70	0.70	0.50	0.60	0.70	0.75	0.90	0 70	0.70	0.65	0.85	0.85
1932	0.95	0.90	0.90	0.95	1.00	0.90	0.75	0.60	0.65	0.50	0.55	0.50
1933	0.50	0.48	0.50	0.50	0.50	0.80	0.55	0.55	0.55	0.60	0.60	0.55

* Interpolated.

Sources of data for tables 38 and 39:

1910-1925: U. S. Dept. Agr. Bur. Agr. Econ. Prices of farm products received by producers. 4. Mountain and Pacific states. U. S. Dept. Agr. Statis. Bul. 17: 140-141. 1927.

Table 38: 1926-1933: Unpublished data obtained from the U. S. Dept. Agr.

Table 39: 1926-1933: U. S. Dept. Agr. Crops and Markets, monthly issues.

TABLE 40

Annual Unweighted Averages of Monthly Farm Prices, California, Calendar Years, 1910–1933

Year beginning January 1	Beef cattle	Veal calves	Hogs	Sheep	Lambs	Milk	Milk fat	Butter	Eggs	Chickens	Wool	Horses
	dollars per 100 pounds	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*cents per pound*	*cents per pound*	*cents per dozen*	*cents per pound*	*cents per pound*	*dollars per head*
1910	5.61	6.08	8 42	5.22	6.14	2.51	35.3	31.4	30 2	14.8	15.8	139
1911	5.68	6.48	6.86	4.72	5.66	2.61	30.4	29.4	27.9	15.0	11.9	155
1912	5.72	6.45	6.45	4.44	5.29	2.75	36.1	32.5	27.8	14.2	14.3	147
1913	6.53	7.04	7.22	4.63	5.52	2.38	36.7	33.0	29.3	14.7	13.8	135
1914	6.62	7.68	7.88	5.01	6.08	2.18	31.0	29.8	30.8	15.5	14.2	124
1915	6.11	7.53	6.68	5.73	6.80	2.15	29.9	28.9	28.9	15.4	18.1	115
1916	6.29	7.59	7.12	6.38	7.51	2.22	33.4	30.5	31.1	16.2	22 2	111
1917	8.00	8.61	12.22	9.54	11.26	2.56	46.2	40.8	37.8	19.3	44.4	112
1918	9.26	9.91	14.96	11.36	13.41	2.95	57.2	51.4	47.1	25.7	50.2	113
1919	9.89	11.33	15.46	9.93	12.01	3.13	67.7	58.7	52.2	30.2	43.5	109
1920	9.24	10.98	13.55	8.78	10.94	3.50	67.6	62.2	49.9	29.4	35.1	109
1921	6 52	8.67	9.49	5.34	7.67	2.83	46.8	44.8	35.5	27.6	11.9	98
1922	6.38	8.16	9.96	6.64	10.00	2.85	46.6	43.5	33.0	25 4	30.2	97
1923	6.20	8.28	8.52	7.61	11.33	2.81	53.8	47.1	34.3	24.0	35.8	95
1924	6.49	7.93	8.20	7.32	10.77	2.58	46.8	47.1	34.9	24.3	34.5	92
1925	6.80	9.06	12.41	8.36	12.48	2.66	53.8	51.7	39.0	26.1	39.5	97
1926	6.95	9.57	13.38	8.05	11.99	2.55	48.2	46.4	33.8	26.2	30.8	88
1927	7.47	10.01	11.02	7.91	11.60	2.67	50.4	47.7	29.8	24.9	28.2	84
1928	9.75	11.60	9.66	8.36	12.19	2.65	51.0	48.0	30.8	25.5	34.3	80
1929	9.62	11.92	10.33	8.27	11.77	2.68	50.8	48.3	34.4	26.8	28.3	80
1930	7.90	10.42	9.92	5.79	8.62	2.48	39.2	39.5	27.9	24.0	18.4	68
1931	5.72	7.60	6.98	3.62	6.10	2.06	28.3	29.8	21.6	20.3	13.2	62
1932	4.54	5.63	4.10	2.62	4.68	1.66	21.7	22.6	18.8	15.7	8.7	50
1933	3.99	5.08	4.12	2.44	5.11	1.52	21.5	21.8	18.7	13.7	15.6	56

Year beginning January 1	Barley	Wheat	Oats	Corn	Hay	Alfalfa	Cotton	Potatoes	Beans	Oranges	Lemons	Apples
	cents per bushel	*cents per bushel*	*cents per bushel*	*cents per bushel*	*dollars per ton*	*dollars per ton*	*cents per pound*	*cents per bushel*	*dollars per bushel*	*dollars per box*	*dollars per box*	*dollars per bushel*
1910	61.0	102.2	56.4	84.9	9.80	9.00	—*	76.0	2.58	—	—	0.96
1911	64.9	87.6	49.8	82.5	9.58	9 52	—	108.3	2.76	—	—	0.86
1912	78.2	95.8	55.9	93.1	13.25	11.23	—	89.8	2.64	1.75	2.79	0.94
1913	68.5	94.4	56.2	84.5	14.28	12.04	—	59.8	2.84	2.75	4.48	0.93
1914	56.2	97.1	50.0	85.7	9.49	6.67	—	68.4	2.71	1.77	2.82	0.99
1915	60.6	109.2	48.7	94.1	9.13	8.48	—	76.8	2.95	1.75	1.95	0.83
1916	71.9	110.1	54.7	97.8	12.23	10.82	—	117.7	3.78	2.32	2.72	0.94
1917	114.2	193.8	84.1	168.3	16.92	16.09	—	186.0	6.49	2.14	2.52	1.07
1918	139.2	212.9	90.8	191.6	20.29	19.34	—	125.9	5.58	4.13	4.15	1.25
1919	132.0	213.8	92.4	186.4	16.92	17.08	—	146.8	4.29	2.97	2.86	1.98
1920	142.4	218.8	99.1	183.0	24.28	22.95	—	286.2	4.13	3.87	2.99	2.05
1921	62.5	131.5	58.4	91.9	13.63	10.71	—	127.2	3.21	2.25	2.36	1.44
1922	64.8	112.2	56.1	93.5	13.70	12.75	19.6	112.8	3.59	3.34	2.79	1.64
1923	73.3	113.1	62.9	98.7	13.53	14.63	27.6	107.0	3.60	2.14	3.42	1.57
1924	94.3	128.2	71.2	126.8	16.59	18.45	27.3	137.3	3.88	2.14	1.94	1.56
1925	88.5	160.3	71.7	137.7	16.61	16.16	23.3	174.6	4.52	4.00	3.39	1.67
1926	58.8	137.3	48.4	109.2	12.52	13.14	16.5	170.1	3.83	2.94	1.99	1.35
1927	78.8	128.2	58.5	117.8	11.76	13.28	16.7	143.3	3.26	3.34	3.61	1.30
1928	83.2	125.4	67.4	125.7	13.42	15.32	18.4	101.2	3.85	4.30	3.63	1.39
1929	73.1	119.2	62.2	119.3	15.41	17.78	18.5	117.1	5.19	2.13	4.42	1.41
1930	53.5	101.0	50.2	106.4	12.98	14 12	13.3	140.8	4.30	4.45	3 48	1 20
1931	46.1	66.0	37.8	72.5	10.01	10.34	8.1	77.1	2.16	1.63	2 68	0 72
1932	34.2	59.4	32.8	57 6	8.25	8.43	6.1	60.6	1.62	1.26	3 32	0 76
1933	34.8	66.1	35.9	59.2	7.50	7.49	8.5	75.0	2.10	1.06	2 33	0 56

* Dashes indicate data not available.

Sources of data:

Calculations by author based on data presented in tables 16 to 39, inclusive.

TABLE 41

ANNUAL UNWEIGHTED AVERAGES OF MONTHLY FARM PRICES, CALIFORNIA, YEARS BEGINNING JULY 1, 1910–1932

Year beginning July 1	Beef cattle	Veal calves	Hogs	Sheep	Lambs	Milk	Milk fat	Butter	Eggs	Chickens	Wool	Horses
	dollars per 100 pounds	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*cents per pound*	*cents per pound*	*cents per dozen*	*cents per pound*	*cents per pound*	*dollars per head*
1910	5.82	6.57	7.89	5.19	6.23	2.54	33.2	30.8	28.8	14.9	13.6	146
1911	5.53	6.23	6.32	4.34	5.12	2.80	33.0	30.9	28.2	14.6	12.6	154
1912	6.14	6.82	6.77	4.69	5.62	2.53	37.3	32.6	27.0	14.1	14.8	142
1913	6.63	7.25	7.72	4.62	5.60	2.24	32.8	31.2	31.0	15.7	13.4	129
1914	6.38	7.77	7.38	5.47	6.48	2.14	31.0	29.5	29.3	15.2	16.5	119
1915	6.15	7.47	6.64	5.98	7.07	2.24	31.2	29.8	29.7	15.6	19.5	112
1916	7.09	8.07	9.09	7.68	9.06	2.32	38.8	34.2	34.3	17.5	30.7	112
1917	8.68	9.12	14.08	10.92	12.92	2.84	50.4	45.9	41.4	22.3	50.8	114
1918	9.89	10.72	15.56	10.86	12.81	2.99	64.3	56.0	49.8	29.1	46.1	111
1919	9.61	11.59	14.51	9.70	11.96	3.32	69.4	61.7	51.1	29.5	44.6	109
1920	7.92	9.76	11.41	6.82	8.97	3.13	55.5	53.0	43.1	28.8	18.7	103
1921	6.08	8.21	9.58	5.39	8.18	2.92	45.5	43.2	34.0	26.6	19.7	96
1922	6.33	8.16	9.46	7.47	11.09	2.82	52.3	46.0	34.5	24.0	36.3	96
1923	6.46	8.28	7.94	7.53	11.12	2.74	51.9	47.9	34.1	24.0	32.7	92
1924	6.49	8.27	10.18	7.68	11.47	2.54	46.9	46.8	37.9	25.3	38.7	97
1925	6.92	9.42	13.20	8.43	12.25	2.60	53.3	51.2	36.5	26.2	35.4	91
1926	7.04	9.68	12.58	7.67	11.67	2.64	49.2	47.0	32.1	26.1	28.3	88
1927	8.62	10.68	9.78	8.25	12.04	2.66	49.5	46.6	29.9	24.5	31.2	81
1928	9.93	12.08	10.27	8.45	12.20	2.67	52.1	49.2	32.5	26.4	32.7	79
1929	9.05	11.32	10.22	7.23	10.52	2.64	45.8	44.5	33.4	26.2	22.5	76
1930	6.60	9.18	8.85	4.48	7.01	2.26	32.6	33.8	23.2	21.9	15.9	65
1931	4.98	6.36	5.13	3.11	5.24	1.83	25.8	26.8	20.9	17.7	10.6	54
1932	4.15	5.08	3.92	2.19	4.50	1.55	20.8	21.7	18.9	14.8	9.5	52

Year beginning July 1	Barley	Wheat	Oats	Corn	Hay	Alfalfa	Cotton	Potatoes	Beans	Oranges	Lemons	Apples
	cents per bushel	*cents per bushel*	*cents per bushel*	*cents per bushel*	*dollars per ton*	*dollars per ton*	*cents per pound*	*cents per bushel*	*dollars per bushel*	*dollars per box*	*dollars per box*	*dollars per bushel*
1910	55.7	91.8	49.2	81.5	9.37	9.85	—*	96.6	2.83	—	—	0.84
1911	79.8	91.8	55.3	89.2	11.32	10.19	—	106.1	2.64	—	—	0.95
1912	69.2	95.4	54.6	88.0	14.11	12.00	—	59.5	2.68	1.94	3.39	0.85
1913	64.0	94.2	54.1	86.1	12.39	9.15	—	70.3	2.84	2.44	3.71	1.12
1914	58.4	110.8	49.5	90.9	8.18	7.14	—	74.8	2.79	1.76	2.54	0.82
1915	60.0	96.8	47.9	90.1	10.95	9.42	—	89.0	3.11	1.83	2.02	0.89
1916	97.1	152.6	71.2	127.3	14.45	13.53	—	176.6	5.39	2.44	2.73	1.00
1917	135.1	208.3	88.8	187.8	19.14	18.62	—	125.8	6.21	2.76	3.26	1.09
1918	119.6	213.6	90.0	191.7	18.39	17.05	—	137.7	4.79	4.07	3.83	1.82
1919	155.5	221.0	99.8	193.4	21.57	21.73	—	250.1	4.40	3.43	3.20	2.07
1920	93.9	178.2	78 1	132.5	18.98	16.12	—	178.4	3.50	2.87	2.03	1.54
1921	62.9	115.2	53.8	88.0	12.78	11.46	16.6	129.2	3.45	2.90	2.87	1.69
1922	68.9	115.3	62.9	96.5	13.67	13.82	23.2	95.9	3.50	2.70	3.17	1.57
1923	72.1	108.6	61.2	108.6	13.74	15.92	30.0	135.9	3.60	1.90	2.33	1.54
1924	109.0	157.9	81.7	141.4	19.20	19.06	24.1	143.5	4.35	3.07	3.04	1.63
1925	68.0	147.2	55.0	118.2	13.35	13.58	20.0	203.4	4.28	3.59	2.81	1.58
1926	61.8	131.9	49.9	110.9	11.97	12.72	14.6	143.8	3.46	2.95	1.81	1.12
1927	91.8	127.2	68.2	123.1	12.47	14.69	18.9	117.5	3.39	3.97	4.68	1.54
1928	74.3	118.9	62.3	125.1	14.73	16.79	18.7	90.4	4.67	3.28	2.82	1.22
1929	65.4	117.1	58.9	112.8	14.72	16.68	16.9	151.7	5.00	3.30	5.08	1.62
1930	46.3	79.2	41.4	90.5	10.68	11.28	10.3	102.9	3.06	3.08	2.75	0.64
1931	44.8	62.8	36.4	65.6	9.89	9.90	6.3	68.8	1.72	1.50	2.37	0.85
1932	25.8	56.0	30.1	52.2	6.82	7.02	6.8	57.2	1.84	1.10	3.69	0.57

* Dashes indicate data not available.

Sources of data:
Calculations by author based on data presented in tables 16 to 39, inclusive.

TABLE 42

Annual Weighted Averages of Monthly Farm Prices, California, Calendar Years, 1910–1933

Year beginning January 1	Beef cattle	Veal calves	Hogs	Sheep	Lambs	Milk	Milk fat	Butter	Eggs	Chickens	Wool	Horses
	dollars per 100 pounds	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*cents per pound*	*cents per pound*	*cents per dozen*	*cents per pound*	*cents per pound*	*dollars per head*
1910	5.63	6.08	8.48	5.23	6.06	2.51	34.8	31.1	29.2	14.9	16.1	139
1911	5.65	6.48	6.83	4.65	6.07	2.61	29.9	29.2	26.8	14.9	12.3	155
1912	5.72	6.45	6.48	4.43	5.37	2.75	35.6	32.3	26.7	14.3	14 8	147
1913	6.53	7.04	7.27	4.55	5.69	2.38	36.5	32.8	27.9	14.7	14.6	135
1914	6.60	7.68	7.91	5.02	6.08	2.18	30.5	29.5	29.4	15.4	14.9	124
1915	6.09	7.53	6.66	5.71	6.88	2.15	29.6	28.7	27.6	15.3	19.3	115
1916	6.30	7.59	7.19	6.39	7.62	2.22	33.0	30.2	29.6	16.1	23.0	111
1917	8.02	8.61	12.46	9.66	11.34	2.56	45.6	40.2	36.3	19.8	47 9	112
1918	9.29	9.91	15.05	11.29	13.81	2.95	56.0	50.7	45.1	26.0	50.1	113
1919	9.85	11.33	15.41	9.79	12 34	3.13	67.2	58.2	50.3	29.8	45.1	109
1920	9.16	10.98	13.59	8.45	11.71	3.50	67.5	62.1	48.0	29.5	35.0	109
1921	6.43	8.67	9.54	5.13	7.62	2.83	46.0	44.4	33.7	27.9	11.4	98
1922	6.39	8.16	10.03	6.64	10.38	2.85	45.7	43.0	31.4	25.2	32.2	97
1923	6.16	8.28	8.53	7.49	11.31	2.81	53.4	46.8	32.8	23.6	36.0	95
1924	6.46	7.93	8.30	7.18	10.95	2.58	46.6	47.0	33.2	24.3	34.3	92
1925	6.82	9.06	12.59	8.22	12.42	2.66	53.1	51.1	37.6	26.0	39.3	97
1926	6.91	9.57	13.45	7.93	11.90	2.55	48.0	46.3	32.5	26.3	30.2	88
1927	7.44	10.01	11.03	7.89	11.80	2.67	50.1	47.5	28.6	25.3	27.8	84
1928	9.72	11.60	9.80	8.31	12.28	2.65	50.4	47.5	29.6	25.8	35.2	80
1929	9.63	11.92	10.40	8.12	12.01	2.68	50.6	48.2	33.1	26.9	27.9	80
1930	7.86	10.42	9.95	5.55	8.79	2.48	39.3	39.5	27.3	24.0	17.5	68
1931	5.65	7.60	6.88	3.52	6.38	2.06	28.1	29.5	20.7	20.2	12.9	62
1932	4.53	5.63	4.10	2.50	4.80	1.66	21.5	22.4	18.1	15.8	8.0	50
1933	4.03	5.08	4.19	2.49	4.92	1.52	21.4	21.7	17.9	13 7	17.1	56

Year beginning January 1	Barley	Wheat	Oats	Corn	Hay	Alfalfa	Cotton	Potatoes	Beans	Oranges	Lemons	Apples
	cents per bushel	*cents per bushel*	*cents per bushel*	*cents per bushel*	*dollars per ton*	*dollars per ton*	*cents per pound*	*cents per bushel*	*dollars per bushel*	*dollars per box*	*dollars per box*	*dollars per bushel*
1910	58.4	101.5	55.2	84.9	9.54	8.89	—*	76.1	2.62	—	—	0.86
1911	66.0	87.4	50.2	82.8	9.32	9.37	—	106.8	2.76	—	—	0.86
1912	75.0	95.4	55.1	93.0	13.00	11.05	—	80.6	2.64	1.77	2.78	0.85
1913	68.8	94.2	56.4	84.8	14.20	12.02	—	63.8	2.87	2.69	4.42	0.96
1914	53.4	97.4	49.6	85.2	8.94	6.52	—	66.9	2.62	1.73	2.77	0.81
1915	57.7	107.6	48.0	93.7	8.99	8.26	—	73.1	2.97	1.71	1.91	0.75
1916	71.6	111.7	55.8	99.0	12.14	10.78	—	119.3	3.84	2.18	2.60	0.89
1917	113.3	194.4	84.6	170.2	16.69	15.82	—	167.7	6.18	2.11	2.42	1.00
1918	135.7	212.8	90.3	192.0	19.84	18.92	—	138.5	5.45	3.95	4.07	1.30
1919	138.7	213.7	93.2	186.3	16.38	16.83	—	153.4	4.35	2.96	2.83	1.69
1920	140.8	217.5	97.9	181.2	23.96	22.62	—	273.1	4.00	3.87	3.03	1.75
1921	60.8	130.0	57.5	91.0	12.83	10.24	—	128.9	3.16	2.19	2.36	1.47
1922	63.1	111.6	56.3	92.8	13.25	12.24	20.9	110.5	3.42	3.37	2.77	1.46
1923	71.2	112.4	61.6	99.2	13.29	14.37	28.9	112.6	3.75	2.11	3.76	1.44
1924	100.1	130.1	73.0	127.7	16.78	18.42	25.3	135.0	4.04	2.00	1.63	1.44
1925	83.4	159.7	68.6	135.3	15.88	15.62	22.8	179.3	4.47	3.87	3.70	1.58
1926	57.5	136.5	47.4	109.8	12.03	12 83	15.7	143.7	3.72	2.88	2.14	1.07
1927	82.6	127.8	59.5	118.8	11.31	12.98	19.6	143.8	3.18	3.16	3.26	1.34
1928	79.4	124.5	65.7	125.7	13.31	15.02	18.7	93.6	3.83	4.20	3.84	1.15
1929	71.9	119.4	61.7	119.1	15.04	17.44	18 3	127.8	5.09	2.06	3.70	1.46
1930	50.8	99.6	48.6	106.5	12.33	13.52	11.6	132.0	3.91	4.34	3.83	0.81
1931	45.9	65.5	37.1	71.9	9.78	10.12	7.0	72.9	2.10	1.60	2.73	0.74
1932	30.3	59.1	31.9	57.3	7.57	7.97	6.6	57.0	1 71	1.26	2.76	0.65
1933	38.0	66 6	37.1	59.2	7.41	7.35	9.1	80 8	2.02	1.00	2 46	0.56

* Dashes indicate data not available.

Sources of data:
Calculations by author based on data presented in table 1 and tables 16 to 39, inclusive.

TABLE 43

Annual Weighted Averages of Monthly Farm Prices, California, Years Beginning July 1, 1910–1932

Year beginning July 1	Beef cattle	Veal calves	Hogs	Sheep	Lambs	Milk	Milk fat	Butter	Eggs	Chickens	Wool	Horses
	dollars per 100 pounds	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*dollars per 100 pounds*	*cents per pound*	*cents per pound*	*cents per dozen*	*cents per pound*	*cents per pound*	*dollars per head*
1910	5.82	6.57	7.97	5.23	6.41	2.54	32.4	30.4	27.6	15.0	14.4	146
1911	5.53	6.23	6.35	4.34	5.25	2.80	32.8	30.9	27.1	14.6	12.9	154
1912	6.12	6.82	6.77	4.62	5.76	2.53	37.0	32.4	25.9	14.1	14.9	142
1913	6.61	7.25	7.71	4.56	5.80	2.24	32.1	30.7	29.6	15.5	14.7	129
1914	6.37	7.77	7.45	5.38	6.69	2.14	30.5	29.1	27.9	15.2	16.8	119
1915	6.16	7.47	6.65	5.91	7.35	2.24	31.1	29.6	28.4	15.3	20.6	112
1916	7.06	8.07	8.99	7.38	10.01	2.32	39.0	34.4	33.4	17.4	31.0	112
1917	8.68	9.12	14.08	10.75	13.55	2.84	50.0	45.9	40.4	22.4	51.4	114
1918	9.83	10.72	15.60	10.91	12.79	2.99	64.2	55.9	48.2	28.9	47.3	111
1919	9.56	11.59	14.55	9.57	12.31	3.32	68.8	61.6	48.9	29.4	45.2	109
1920	7.92	9.76	11.66	6.93	8.42	3.13	53.7	51.7	40.1	29.2	21.6	103
1921	6.09	8.21	9.66	5.14	9.30	2.92	44.7	42.6	32.2	26.8	19.0	96
1922	6.30	8.16	9.53	7.31	11.16	2.82	52.0	45.8	32.9	23.6	36.6	96
1923	6.41	8.28	8.01	7.45	11.15	2.74	51.1	47.7	32.6	23.9	33.1	92
1924	6.50	8.27	10.14	7.41	11.83	2.54	47.0	46.8	36.7	25.1	37.2	97
1925	6.89	9.42	13.26	8.36	12.05	2.60	52.5	50.5	34.8	26.3	35.9	91
1926	7.01	9.68	12.71	7.61	11.85	2.64	49.0	47.0	30.6	26.3	28.6	88
1927	8.53	10.68	9.90	8.16	12.19	2.66	49.1	46.3	28.8	24.9	30.7	81
1928	9.91	12.08	10.38	8.34	12.29	2.67	51.8	48.8	31.5	26.7	33.1	79
1929	9.06	11.32	10.28	7.32	9.90	2.64	45.2	43.9	32.0	26.2	23.1	76
1930	6.61	9.18	8.97	4.56	6.93	2.26	31.9	33.2	22.0	22.1	15.8	65
1931	4.98	6.36	5.23	3.11	5.14	1.83	25.1	26.2	19.8	17.9	10.7	54
1932	4.19	50.8	3.94	2.18	4.55	1.55	20.7	21.5	18.1	14.9	9.7	52

Year beginning July 1	Barley	Wheat	Oats	Corn	Hay	Alfalfa	Cotton	Potatoes	Beans	Oranges	Lemons	Apples
	cents per bushel	*cents per bushel*	*cents per bushel*	*cents per bushel*	*dollars per ton*	*dollars per ton*	*cents per pound*	*cents per bushel*	*dollars per bushel*	*dollars per box*	*dollars per box*	*dollars per bushel*
1910	56.0	92.2	49.8	81.8	9.22	9.70	—*	89.5	2.81	—	—	0.85
1911	75.2	91.0	54.3	88.9	10.71	9.93	—	103.2	2.66	—	—	0.88
1912	69.6	95.2	54.2	88.4	13.72	11.89	—	63.9	2.65	2.01	3.47	0.82
1913	64.6	94.1	54.8	86.1	12.51	9.19	—	69.3	2.88	2.29	3.55	1.01
1914	54.6	109.7	49.1	89.8	8.11	6.98	—	71.2	2.66	1.72	2.42	0.76
1915	58.0	96.7	47.6	90.2	10.40	9.20	—	80.2	3.11	1.80	1.98	0.77
1916	89.6	149.3	67.9	126.0	13.99	13.24	—	153.9	4.81	2.34	2.63	0.90
1917	127.5	207.9	88.0	188.3	18.19	17.94	—	135.9	6.18	2.84	3.26	1.01
1918	124.4	213.5	89.8	191.9	18.34	17.03	—	144.9	4.90	3.86	3.69	1.43
1919	152.8	220.2	98.6	192.7	20.14	20.95	—	215.7	4.46	3.53	3.14	1.71
1920	106.4	181.2	82.9	135.6	19.57	16.26	—	206.8	3.48	2.69	2.03	1.63
1921	61.8	114.8	53.7	86.4	12.34	11.01	17.1	129.9	3.26	3.00	3.03	1.53
1922	65.5	114.6	61.4	96.1	13.27	13.37	22.3	100.4	3.45	2.59	3.23	1.44
1923	70.3	108.3	60.4	108.2	13.61	15.72	30.3	131.3	3.72	1.83	2.38	1.43
1924	109.6	157.2	81.2	140.9	18.65	18.59	23.7	139.9	4.41	3.11	3.21	1.46
1925	69.2	147.5	56.0	117.9	13.26	13.40	21.5	188.5	4.28	3.39	2.78	1.55
1926	61.6	131.7	48.4	111.3	11.58	12.45	14.6	140.0	3.47	2.85	1.95	1.02
1927	89.8	126.5	66.6	123.4	12.04	14.30	20.7	118.3	3.17	3.95	4.47	1.42
1928	73.4	118.8	62.0	125.1	14.30	16.43	18.9	92.6	4.51	2.95	2.88	1.10
1929	66.4	117.5	59.4	113.3	14.32	16.13	17.8	145.1	4.93	3.50	4.63	1.52
1930	46.9	79.9	41.9	91.9	10.66	11.13	10.3	108.8	3.04	2.73	2.83	0.67
1931	43.4	62.6	36.2	65.5	9.48	9.53	6.3	67.8	1.79	1.44	2.37	0.77
1932	25.7	55.9	29.8	52.2	6.64	6.86	6.7	54.7	1.79	1.05	3.30	0.59

* Dashes indicate data not available.

Sources of data:
Calculations by author based on data presented in table 1 and tables 16 to 39, inclusive.

TABLE 44

Estimated Seasonal Farm Prices, California, 1910–1933

Year	Rice	Cotton	Sugar beets	Grapes	Peaches	Pears	Apricots	Cherries	Raisins	Prunes	Walnuts	Almonds
	dollars per bushel	*cents per pound*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*	*dollars per ton*
1910	0.65	13.3	—*	11	18	41	30	100	55	110	264	226
1911	0.75	7.5	—	11	35	34	49	116	81	125	244	268
1912	0.91	12.5	—	11	17	33	29	98	62	90	244	214
1913	1.00	13.0	—	19	19	47	45	120	70	115	282	286
1914	1.00	7.0	—	13	15	40	37	136	73	115	292	280
1915	0.90	11.2	—	16	9	25	25	112	77	100	238	210
1916	0.78	20.0	6.30	21	21	54	46	136	95	130	272	276
1917	1.75	28.0	7.60	23	32	56	56	150	110	140	350	282
1918	1.90	30.0	9.95	44	41	74	55	172	117	200	500	386
1919	2.67	43.0	14.17	55	65	80	87	200	222	300	566	390
1920	1.21	30.0	13.13	86	69	101	81	224	262	220	396	282
1921	1.15	17.0	7.51	82	34	66	55	106	158	130	442	276
1922	1.10	—	10.14	62	48	55	76	208	64	150	400	298
1923	1.12	—	13.99	40	26	46	31	196	49	120	394	230
1924	1.66	—	9.14	34	36	74	51	118	60	110	450	288
1925	1.70	—	8.21	24	36	53	61	176	76	120	410	390
1926	1.31	—	9.25	27	40	37	69	190	63	100	484	330
1927	1.13	—	9.28	28	24	57	57	166	55	80	314	312
1928	0.88	—	8.03	17	22	45	52	158	43	110	430	350
1929	1.05	—	7.28	32	62	79	69	196	67	190	324	446
1930	0.83	—	7.46	15	20	26	38	148	58	65†	364	210
1931	0.56	—	7.39	26	15	30	25	80	68	50†	274	162
1932	0.36	—	6.50	12	8	11	20	60	36	55†	200†	164
1933	0.74	—	8.00†	18†	20†	18†	30†	80	57†	80†	202†	182

* Dashes indicate data not available.

† Subject to revision.

Sources of data: See discussion of sources of data in Appendix A on pages 43 to 47.

TABLE 45

ANNUAL INDEX NUMBERS OF FARM PRICES, CALIFORNIA, YEARS BEGINNING JULY 1, 1910–1932

(July, 1924 to June, 1929 = 100)

Year beginning July 1	All products	Livestock and livestock products				Crops			
		All	Meat animals	Dairy products	Poultry products	All	Grains	Field crops other than grains	Fruits
1910	70	75	68	80	81	67	64	68	68
1911	75	73	61	84	80	76	78	63	86
1912	70	75	67	84	76	67	76	68	66
1913	78	75	72	74	87	79	75	65	84
1914	68	73	72	70	83	65	76	53	66
1915	68	74	70	72	84	65	72	67	63
1916	90	87	85	82	97	92	103	109	87
1917	111	112	113	104	117	111	153	129	99
1918	133	128	124	122	142	136	149	121	139
1919	152	131	120	133	146	163	182	156	163
1920	133	108	96	114	125	147	115	118	165
1921	109	91	78	100	101	119	82	84	137
1922	105	97	84	106	101	109	85	94	120
1923	91	95	82	104	100	89	85	113	83
1924	104	97	88	95	110	108	125	116	104
1925	104	103	99	103	107	105	102	105	106
1926	93	97	98	99	96	91	88	87	91
1927	102	98	102	100	90	104	100	92	110
1928	96	105	113	103	97	91	85	101	89
1929	109	98	104	95	99	115	82	106	126
1930	74	74	79	74	71	75	59	71	78
1931	58	58	55	60	63	59	49	52	62
1932	46	48	45	49	56	45	35	45	47

Sources of data: Calculations by the author based on data presented in tables 7, 8, 41, and 44.

TABLE 46

ANNUAL INDEX NUMBERS OF FARM PRICES, CALIFORNIA, CALENDAR YEARS, 1910–1933

(1910–1914 = 100)

Year beginning January 1	All products	Livestock and livestock products				Crops			
		All	Meat animals	Dairy products	Poultry products	All	Grains	Field crops other than grains	Fruits
1910	96	102	100	102	103	91	95	99	90
1911	99	96	95	98	96	101	94	98	111
1912	96	100	93	109	95	94	110	110	85
1913	113	102	104	102	100	120	105	111	122
1914	96	100	109	89	105	94	97	82	92
1915	93	96	103	87	99	90	102	98	84
1916	114	103	108	94	107	120	107	139	116
1917	143	136	150	119	130	147	189	212	121
1918	186	163	177	142	163	198	216	210	189
1919	203	176	182	161	181	218	228	218	213
1920	216	171	167	169	174	240	205	236	250
1921	147	123	119	125	128	160	117	132	172
1922	149	125	124	125	119	161	111	147	172
1923	132	130	121	135	122	132	118	170	122
1924	133	124	121	120	124	138	150	182	120
1925	154	140	143	132	138	162	158	182	154
1926	133	132	147	121	122	134	120	153	126
1927	134	129	144	127	109	136	127	142	134
1928	142	137	162	127	112	144	124	150	142
1929	147	140	163	128	124	150	118	174	148
1930	128	116	137	107	102	134	97	148	135
1931	87	87	98	83	80	87	69	94	86
1932	67	68	72	66	69	66	54	75	65
1933	71	66	67	62	67	74	65	85	71

Sources of data: Calculations by the author based on data presented in tables 7, 8, 40, and 44.

TABLE 47

ANNUAL INDEX NUMBERS OF FARM PRICES, CALIFORNIA, CALENDAR YEARS, 1910–1933
(1924–1928 = 100)

Year beginning January 1	All products	Livestock and livestock products				Crops			
		All	Meat animals	Dairy products	Poultry products	All	Grains	Field crops other than grains	Fruits
1910	71	77	70	82	85	67	70	62	69
1911	74	73	66	78	79	74	69	61	85
1912	69	75	65	87	79	66	81	69	63
1913	82	77	72	81	83	84	77	70	90
1914	69	76	76	71	87	66	72	51	68
1915	67	73	72	70	82	63	75	62	62
1916	82	78	75	75	88	84	79	86	85
1917	103	103	104	95	107	103	139	131	90
1918	134	123	123	113	134	139	159	130	140
1919	146	133	127	128	150	153	169	135	157
1920	155	129	117	134	144	168	151	146	184
1921	105	93	83	100	106	112	86	81	127
1922	107	94	86	100	98	113	82	91	127
1923	94	98	85	107	101	93	87	105	91
1924	96	94	84	96	102	97	111	113	89
1925	111	106	100	105	114	113	116	112	114
1926	96	100	103	97	101	94	88	94	93
1927	96	98	100	101	90	95	93	88	99
1928	102	104	113	102	93	101	91	93	105
1929	105	105	114	102	103	105	87	108	109
1930	92	88	95	86	85	94	71	92	100
1931	63	66	68	66	66	62	51	58	65
1932	48	51	50	52	57	47	40	46	48
1933	51	50	47	50	55	52	48	53	53

Sources of data: Calculations by the author based on data presented in tables 7, 8, 40, and 44.

TABLE 48

Annual Index Numbers of Farm Prices, United States, Calendar Years 1910–1933*

(1910–1914 = 100)

Year beginning January 1	All products	Livestock and livestock products			Grains	Crops	
		Meat animals	Dairy products	Poultry products		Fruits and vegetables	Cotton and cottonseed
1910	103	102	100	104	104	91	118
1911	95	86	97	90	96	106	104
1912	99	94	103	101	106	110	90
1913	100	108	101	100	92	92	101
1914	103	111	100	105	103	101	88
1915	101	103	98	102	120	83	80
1916	117	118	102	116	126	123	124
1917	176	171	125	156	217	202	194
1918	200	199	152	185	226	162	254
1919	209	204	173	205	231	189	256
1920	205	170	188	221	231	249	258
1921	118	107	148	160	112	148	105
1922	123	111	134	139	105	152	161
1923	134	105	148	145	114	136	223
1924	134	108	134	146	129	124	219
1925	147	138	137	161	156	160	183
1926	136	144	136	155	129	189	126
1927	131	137	138	140	128	155	133
1928	139	149	140	149	130	146	158
1929	138	154	140	158	121	136	150
1930	117	132	123	126	100	158	106
1931	80	92	94	96	63	98	65
1932	57	63	70	80	44	71	48
1933	63	59	69	74	62	80	66

* Index numbers converted to the 1910-1914 base by considering the unweighted average of the sixty monthly index numbers for this period, on the August, 1909 to July, 1914 base, as equal to 100.

Sources of data:
1910-1930: U. S. Dept. Agr. Yearbook of Agriculture, **1931**: 1018-1020. 1931.
1931-1933: U. S. Dept. Agr. The agricultural situation, monthly issues.

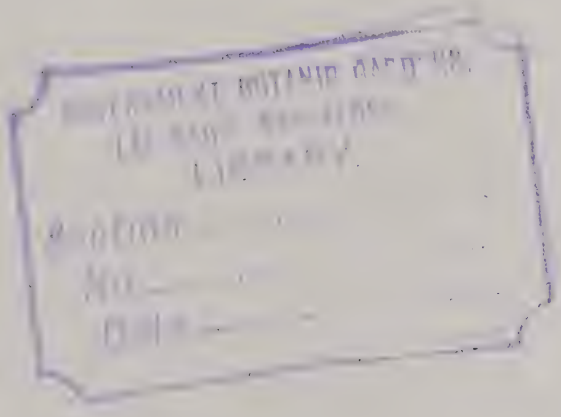
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THE PHOSPHATE OF SOUTHERN CALIFORNIA SOILS IN RELATION TO CITRUS FERTILIZATION

H. D. CHAPMAN

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UNIVERSITY OF CALIFORNIA
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The Phosphate of Southern California Soils in Relation to Citrus Fertilization[1, 2]

H. D. CHAPMAN[3]

FIELD EXPERIMENTATION and general experience have proved conclusively that it is necessary to apply *nitrogenous* fertilizers to the majority of California soils in order to maintain citrus-fruit yields and tree vigor. On the other hand, none of the long-continued fertilizer experiments with citrus trees have given any evidence of need for *phosphate* fertilizers. These experiments furnish substantial support for the belief that, at least in so far as citrus is concerned, southern California soils are well supplied with available phosphate.

In spite of this evidence many citrus growers annually apply large quantities of phosphate or phosphorus-containing materials to their groves. The continuation of this practice is accounted for by the prevalence of various ideas among orchardists. Some believe that the use of nitrogen alone produces fruit of poor quality and that it is necessary to balance the nitrogen with phosphate or potash or both. Still others are influenced by the idea that the amounts of those elements which are removed by the crop should be replaced by fertilizer application. Again others, in lieu of specific information regarding the phosphate of their particular soils, prefer to apply phosphate, feeling that excessive amounts will do no harm whereas a deficiency might prove detrimental; in other words they believe that it is safer to apply phosphate than to omit it.

A scientific system of fertilization is one designed to add to the soil only such elements as are actually deficient. As long as the supply of a given constituent in a soil suffices to meet the needs of the crop or crops being grown, it would seem unnecessary to add more to it, particularly in view of the fact that a part of the applied material may be lost by leaching or else be fixed by the soil in an unavailable form. The perennial question confronting every citrus grower then, is whether or not the supply of essential elements in his particular orchard is sufficient to meet the needs of the trees. In the absence of specific data on his soil, the grower should be guided by such information and experience as can be brought to bear on his particular case.

[1] Received for publication October 16, 1933.

[2] Paper No. 292, University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

[3] Assistant Chemist in the Citrus Experiment Station.

Results recently secured in the course of chemical and pot-culture investigations have provided further evidence that, in so far as citrus is concerned, the majority of the soils of southern California are well supplied with available phosphate. For the benefit of those who are interested in citrus culture these results are here presented. The field experimental evidence which bears on this question is also reviewed briefly.

CHEMICAL AND POT-CULTURE STUDIES

A large number of soil samples representing most of the important soil types of southern California have been collected and analyzed for phosphate. Many of these were drawn from places where it was known definitely that no fertilizer had ever been applied. The data obtained from these samples afford a fairly reliable basis for judgment as to the phosphate conditions in the unfertilized soils of these various types. At the same time samples were taken from many citrus orchards, and a comparison of the data obtained from these with those of nearby unfertilized soils has made it possible to draw reasonably reliable conclusions concerning the effects of previous orchard management on the phosphate content of the soil. Coincident with these chemical studies, pot cultures have been made in order to secure further information concerning the adequacy and availability of the phosphate of the various soil types.

METHODS OF SAMPLING AND ANALYSIS

Soil samples each composed of from 6 to 8 individual cores were taken from representative parts of typical citrus orchards in the various citrus districts and also from nearby unfertilized soil. In most cases the samples represent the first 6 inches, the second 6 inches, and the second foot of the soil, respectively.

The samples were brought to the laboratory, air dried, and screened; water-soluble phosphate was determined in an extract of the soil made by shaking 100 grams of soil with 500 cc of CO_2-free water. Acid-soluble phosphate was determined by digesting 2 grams of soil with 400 cc of 0.002 N sulfuric acid; this solvent buffered with potassium sulfate to pH 3.0. This is a minor modification of the Truog[4] method. Total phosphate was determined by the sodium carbonate fusion method. The blue colorimetric method was used for measuring the phosphate content of the various extracts of the soil.

[4] Truog, E. The determination of the readily available phosphorus of soils. Jour. Amer. Soc. Agron. 22:874–882. 1930.

PHOSPHATE IN CITRUS ORCHARDS AND ADJACENT UNFERTILIZED AREAS

The analytical results are brought together in table 1. They show that without exception the orchard soils are higher, either in water-soluble phosphate or acid-soluble phosphate, or both, than the adjacent unfertilized soils; in many cases the difference is very striking. This is undoubtedly due to the fact that citrus groves have been fertilized with phosphatic materials in amounts sufficient, not only to compensate for that removed by the crops of fruit and growth of the citrus trees, but also to augment the original phosphate content of the soil substantially. Since increases in phosphate over that of the adjacent unfertilized soil were found in every orchard irrespective of the age of the trees or the locality, it is safe to conclude that most citrus orchards of California now contain more phosphate than they did originally.

Animal manures and various kinds of bulky organic materials, such as alfalfa hay and bean straw, are commonly applied to citrus orchards as fertilizers. The extensive use of these materials has arisen largely because of the recognized need for nitrogen and organic matter in citrus soils. However, these materials contain notable amounts of phosphorus and potassium,[5] and it is probable that no small part of the accumulated phosphate is to be accounted for by the extensive use of these materials. For example, animal manures or other bulky organic materials are the only fertilizers that have ever been applied to the areas from which samples 1, 9, 10, 40, and 48 were drawn. The results show that in every one of these soils there has been a substantial increase in phosphate. Many of the samples were drawn from orchards that had been fertilized with moderate to heavy applications of commercial phosphates and these also show marked gains.

Since the data shown in table 1 indicate that the citrus orchards of various localities have made important gains in phosphate in consequence of previous fertilization, the question arises, is the amount now present in the soils adequate to meet the needs of citrus trees? The adequacy of the phosphate in a soil for a given crop is determined chiefly by the following factors: (1) The distribution of the phosphate in the soil, especially in relation to the rooting habits of the crop, (2) the supply and availability of the phosphate present, and (3) the phosphate requirements of the plant in question. Although full information regarding all of these is not available, sufficient evidence is at hand to justify reasonably valid conclusions as to present needs for phosphate fertilization.

[5] Batchelor, L. D. Fertilizing citrus trees with special reference to the use of and the supplementing of manure. California Citrogr. 18:266, 298. 1933.

TABLE 1

PHOSPHATE IN THE CITRUS ORCHARD SOILS AND ADJACENT UNFERTILIZED AREAS

Location	Soil type	Comparison No.	Crop	Fertilizer treatment	Age of grove, years	Water-soluble			Acid-soluble		
						0–6 inches	6–12 inches	12–24 inches	0–6 inches	6–12 inches	12–24 inches
						Parts per million PO_4 in dry soil					
Hemet Valley	Hanford sandy loam	1	Grain	None	....	7.1	6.0	4.6	144	192	162
			Oranges	Oat straw	40	8.8	5.2	3.6	350	308	318
	Hanford sandy loam	2	Grain	None	....	8.0	8.0	4.9	216	216	262
			Oranges	Manure, complete commercial	25	33.0	21.7	18.3	982	740	288
Moreno Valley	Ramona loam	3	Grain	None	....	9.5	3.9	3.4	378	346	320
			Oranges	Manure, complete commercial	35–38	36.9	19.1	14.3	972	416	218
	Ramona loam	4	Grain	None	....	9.1	7.6	4.6	178	172	182
			Oranges	Straw, complete commercial	27–30	32.6	15.2	9.5	880	348	244
	Ramona loam	5	Grain	None	....	4.8	4.4	3.2	118	96	102
			Oranges	Manure, alfalfa hay, complete commercial	9	82.6	40.7	19.7	668	236	198
Corona	Yolo loam	6	Grain	None	....	8.8	8.8	4.5	163	163	148
			Oranges	Manure, fish meal, blood	29	21.2	8.2	7.2	644	240	163
Arlington Heights	Placentia loam	7	Grain	None	....	.....	.....	.....	282	282	276
			Oranges	Manure, complete commercial	35	20.7	20.7	9.3	1,680	1,680	348
Riverside (Victoria Avenue section)	Placentia loam	8	Grain	None					236	236	224
			Oranges	Manure, complete commercial	35	35.2	35.2	21.3	1,590	1,590	488
Riverside (Rubidoux fertilizer plots)	Sierra loam	9	Oranges	None	....	5.7	3.6	2.9	370	342	430
			Oranges	Manure	23	38.0	24.4	14.6	966	706	456

TABLE 1—*Continued*

Location	Soil type	Comparison No.	Crop	Fertilizer treatment	Age of grove, years	Water-soluble			Acid-soluble		
						0–6 inches	6–12 inches	12–24 inches	0–6 inches	6–12 inches	12–24 inches
						Parts per million PO_4 in dry soil					
Riverside (Citrus Experiment Station, Field I)	Ramona loam	10	Oranges	None	....	9.7	7.3	4.5	167	135	114
			Oranges	Manure	16	24.4	15.5	6.4	259	177	128
Riverside (Iowa Avenue section)	Hanford sandy loam	11	Native vegetation	None	....	1.0	1.0	.....	40	40	.....
			Oranges	Manure, complete commercial	40	7.6	7.6	4.6	1,440	1,440	262
			Oranges	Manure, complete commercial	32	4.4	4.4	1.7	752	752	284
Riverside and Highgrove	Ramona loam	12	Native vegetation	None	....	7.1	3.4	1.9	107	98	100
			Oranges	Manure, complete commercial	40	24.0	24.0	9.0	1,295	1,295	264
			Oranges	Manure, tankage, complete commercial	35	64.5	64.5	8.1	2,240	2,240	332
			Oranges	Manure, complete commmercial	35	10.2	10.2	3.6	1,220	1,220	222
			Oranges	Manure, complete commercial	35-40	8.0	8.0	6.1	785	785	326
			Oranges	Manure, tankage, phosphate	34	12.5	12.5	6.1	1,470	1,470	270
	Placentia loam	13	Grain	None	....	3.1	2.8	3.5	196	183	183
			Oranges	Commercial orchard practice*	35	8.5	2.5	2.5	475	206	200
	Hanford sandy loam	14	Grain	None	....	7.5	6.1	6.5	344	306	318
			Oranges	Manure, complete commercial	18	16.1	9.8	8.5	770	378	344
Bryn Mawr	Yolo sandy loam	15	Grain	None	....	16.1	2.0	1.2	630	418	336
			Oranges	Commercial orchard practice*	Unknown	15.3	13.1	2.8	1,720	1,550	520
	Hanford sandy loam	16	Alfalfa	None	....	0.5	0.4	0.4	294	302	268
			Oranges	Alfalfa hay, complete commercial	18	19.6	8.5	5.5	1,300	980	726

* Nature of fertilizers used not definitely known.

TABLE 1—*Continued*

Location	Soil type	Comparison No.	Crop	Fertilizer treatment	Age of grove, years	Water-soluble			Acid-soluble		
						0-6 inches	6-12 inches	12-24 inches	0-6 inches	6-12 inches	12-24 inches
						Parts per million PO_4 in dry soil					
Redlands	Hanford fine sandy loam	17	Alfalfa	None	....	.....	.....	.....	252	260	252
			Oranges	Manure, complete commercial	27	.....	.....	.....	1,000	392	260
	Hanford sandy loam	18	Grapes	None		3.6	2.4	2.0	172	152	160
			Oranges	Commercial orchard practice*	Unknown	14.2	10.0	9.9	860	228	176
	Placentia loam	19	None	None	....	4.8	2.3	0.6	108	100	38
			Oranges	Commercial orchard practice*	Unknown	21.7	5.3	3.5	452	198	116
	Placentia loam	20	None	None	....	8.3	5.1	3.6	480	152	62
			Oranges	Manure, alfalfa hay, cottonseed meal	30	16.8	27.3	22.2	1,380	764	224
East Highlands	Hanford sandy loam	21	Native vegetation	None					114	114	136
			Oranges	Complete commercial	13	89.0	89.0	9.0	764	248	198
			Oranges	Complete commercial	40	13.0	13.0	12.0	1,920	1,920	336
			Oranges	Complete commercial	42	57.0	57.0	21.0	2,560	2,560	342
Fontana	Hanford sandy loam	22	Oranges	None	....	9.7	8.9	8.1	172	178	186
			Oranges	Garbage manure, superphosphate	18	133.4	38.1	29.1	1,280	434	308
Alta Loma	Hanford sandy loam	23	Grain	None	....	5.1	2.5	2.2	284	284	290
			Oranges	Manure, complete commercial	35	52.7	20.6	4.1	1,477	816	228
Ontario	Hanford sandy loam	24	Oranges	Ammonium sulfate	28	13.0	3.4	4.6	266	152	194
			Oranges	Complete (6-8-4)	28	37.0	44.0	28.0	880	662	342

TABLE 1—*Continued*

Location	Soil type	Comparison No.	Crop	Fertilizer treatment	Age of grove, years	Water-soluble			Acid-soluble		
						0–6 inches	6–12 inches	12–24 inches	0–6 inches	6–12 inches	12–24 inches
						Parts per million PO_4 in dry soil					
La Verne	Ramona loam	25	Grain	None	....	8.5	6.2	4.1	179	131	117
			Lemons	Manure, some commercial mixed	Unknown	33.6	18.7	4.6†	750	484	252
Covina	Hanford fine sandy loam	26	Walnuts	None	...	7.5	1.7	3.2	760	652	760
			Oranges	Manure, commercial mixed	18	38.3	15.5	6.8	1,295	850	780
Azusa	Hanford loam	27	Native vegetation	None	....	7.1	3.0	2.9	300	356	486
			Oranges	Manure, commercial	10	39.2	14.5	4.8	1,430	1,070	850
San Fernando	Hanford sandy loam	28	Grain	None	....	6.6	6.6	4.9	422	422	512
			Oranges	Manure, blood	20	24.0	13.9	8.7	1,430	1,160	920
Chatsworth	Yolo loam	29	Beans	None	...	13.6	13.6	8.2	1,028	1,028	1,095
			Oranges	Manure, bean straw	16	44.5	35.4	34.1	1,900	1,500	1,466
Zelzah	Yolo silty clay loam	30	Alfalfa	None	....	1.6	1.6	0.6	1,534	1,534	928
			Oranges	Manure, bean straw	9	5.1	1.5	0.8	1,636	1,500	960
Piru	Yolo loam	31	Alfalfa	None	....	0.5	0.5	0.3	905	905	905
			Oranges	Manure, complete commercial	22	89.2	24.5	12.0	2,920	2,072	1,114
Bardsdale	Yolo silty clay loam	32	Walnuts	None	27	2.6	2.6	2.0	2,400	2,400	2,032
			Oranges	Manure, blood	14	12.1	5.5	2.8	2,732	2,558	2,308
Santa Paula	Yolo silty clay loam	33	Walnuts	None	25	8.2	8.2	1.3	1,262	1,262	1,094
			Oranges	Manure, bean straw	10	3.2	0.6	0.9	1,602	1,228	1,160

† 12–15 inches.

TABLE 1—*Continued*

Location	Soil type	Comparison No.	Crop	Fertilizer treatment	Age of grove, years	Water-soluble			Acid-soluble		
						0–6 inches	6–12 inches	12–24 inches	0–6 inches	6–12 inches	12–24 inches
						Parts per million PO_4 in dry soil					
Fullerton	Ramona loam	34	Grain	None	....	0.3	0.5	0.2	27	22	14
			Lemons	Manure, commercial	Unknown	18.2	3.7	0.03	146	17	9
	Hanford loam	35	Walnuts	None	...	2.2	2.2	2.2	207	207	273
			Oranges	Not known	14	6.1	2.1	0.9	1,020	800	635
Whittier	Ramona loam	36	Grain	None	....	0.2	0.6	0.6	15	15	26
			Oranges	Manure, commercial	16	36.5	8.0	0.1	630	122	15
La Habra	Ramona clay loam	37	Walnuts	None	25	8.3	2.0	1.6	486	546	750
			Oranges	Manure, commercial	25	34.0	19.4	4.8	1,920	810	486
Santa Ana	Hanford sandy loam	38	Grain	None	.	0.3	0.3	0.3	114	114	63
			Oranges	Superphosphate	15	7.0	2.0	Trace	620	392	148
Tustin	Yolo loam	39	Walnuts	None	...	0.1	0.1	Trace	290	290	86
			Oranges	Manure, complete commercial	15	8.8	0.1	Trace	570	293	179
Irvine	Yolo clay adobe	40	Beans	None	. .	6.1	3.5	1.1	560	606	584
			Oranges	Manure, bean straw	18	21.2	13.2	3.0	654	604	702
Fallbrook	Vista loam	41	Grain	None	.	0.5	0.3	0.3	21	15	15
			Oranges	Manure, commercial	25	14.3	1.6	0.5	62	33	22
Escondido	Fallbrook sandy loam	42	Grain	None		0.7	0.6	0.6	60	58	52
			Oranges	Bean straw, Ammophos	3	13.9	2.1	0.4	149	69	43
	Fallbrook sandy	43	Grain	None	.	0.2	0.3	0.1	15	15	20

TABLE 1—*Concluded*

Location	Soil type	Comparison No.	Crop	Fertilizer treatment	Age of grove, years	Water-soluble			Acid-soluble		
						0–6 inches	6–12 inches	12–24 inches	0–6 inches	6–12 inches	12–24 inches
						Parts per million PO_4 in dry soil					
Lemon grove	Montezuma clay adobe	44	Grain	None	....	1.1	1.0	1.1	17	24	29
			Lemons	Manure, chiefly	15	23.0	2.8	1.2	620	178	102
Chula Vista	Aliso clay loam	45	Native vegetation	None	....	1.4	1.5	1.4	17	15	15
			Lemons	Manure, commercial	45	43.3	11.7	2.8	480	192	82
	Aliso clay loam	46	Grain	None	....	3.7	0.3	0.3	22	24	21
			Lemons	Manure, commercial	45	61.8	25.2	4.1	1,430	920	204
El Cajon Valley	Fallbrook sandy loam	47	Grain	None	....	5.4	4.4	2.8	204	192	122
			Oranges	Manure, commercial	25	86.7	46.7	34.0	886	334	272
Imperial Valley	Meloland fine sandy loam	48	Grapefruit	None	2	Trace	Trace	Trace	84	84	74
			Grapefruit	Manure	5	8.4	8.4	5.5	180	180	168
Coachella Valley	Coachella fine sand	49	Alfalfa	None	....	0.7	0.4	Trace	192	334	358
			Grapefruit	Manure, alfalfa hay, rock phosphate	14	8.9	3.8	0.7	370	388	332

DISTRIBUTION OF PHOSPHATE IN RELATION TO CITRUS ROOTING HABITS

Referring to table 1 it will be noted that although the added phos phate has accumulated to a considerable extent in the surface, more o less downward movement has occurred. With but few exceptions, eithe the water-soluble data or acid-soluble data, or both, show evidence o significant penetration into the second six inches of soil; moreover, i many cases the movement of phosphate has extended into the secon foot as well.

In most citrus orchards absorbing roots are especially abundant in th zone immediately below the depth of cultivation. During winter month when cultural operations are largely discontinued, the writer has ofte observed active citrus roots within one or two inches of the surface. Th shallow rooting habit of the citrus tree, on the one hand, together wit the evidence as to phosphate penetration, on the other, justifies the be lief that a portion at least of the phosphate which has accumulated i citrus soils is capable of being utilized.

SUPPLY AND AVAILABILITY OF THE PHOSPHATE PRESENT

The results of extended experiments with pot cultures of oats an alfalfa on representative unfertilized soils have shown that those whic contain roughly from 100 to 150 parts per million of PO_4, as measure by Truog's acid extraction method, are amply supplied. Except in soil which contain calcium carbonate this phosphate is usually readil available. Reference to table 1 (acid-soluble data) shows that of the 5 orchard soils sampled, only 3 contain less than 100 parts per million o PO_4; many contain amounts greatly in excess of this quantity. More over, most of the contiguous unfertilized soils likewise contain phos phate in amounts exceeding this quantity.

However, the unfertilized soils from certain areas, notably Fallbrook Escondido, Chula Vista, Imperial Valley, and certain of the Ramon soil types found in Orange and Los Angeles counties are somewhat lo in phosphate. Other data in harmony with those of table 1, but not in cluded in this bulletin, substantiate this general conclusion. In addition as previously mentioned, pot cultures with oats and alfalfa have show that the phosphate in calcareous soils, though readily soluble in dilut acid, is less available than in noncalcareous types. This latter observa tion is in harmony with results obtained by workers elsewhere.

The question arises, is the supply or availability of phosphate in th above-mentioned types too low to meet citrus needs? The conditions o low supply and availability noted are based on the behavior of quick growing plants. As already stated one of the important factors involve

in the question of phosphate adequacy is the phosphate requirement of the particular plant in question. It is well known that plants differ markedly in this respect. For example, many investigators have observed that buckwheat will make satisfactory growth in soil which contains a supply of phosphate entirely inadequate for another crop, such as tomatoes. The reasons for such differences are not fully understood. Length of growing season, character of the root systems, differences in the growth habits and metabolism of different plants are all involved.

Although little is known about the phosphate requirements of citrus in relation to that of quick-growing plants, certain deductions can be made based (1) on the comparative composition and length of growing season of the two, and (2) on the results of certain phosphate fertilizer experiments.

TABLE 2

PHOSPHATE REMOVAL BY VARIOUS CROPS*

Crop	Yield	Phosphate, (PO_4) in pounds
Wheat	30 bushels	28.2*
Barley	40 bushels	27.7*
Oats	45 bushels	25.9*
Maize	30 bushels	24.1*
Red clover	2 tons	33.3*
Potatoes	6 tons	28.8*
Citrus fruit and new growth	22,500 pounds fresh fruit, 4,653 pounds (dry weight) tree growth (calculated annual growth)	32.69†

* The figures represent phosphate removal by the entire harvested crop. The data for the field crops are taken from: Lyon, T. L., and H. O. Buckman. The nature and properties of soils. The MacMillan Co., New York. p. 245. 1929.

† The figures for citrus fruit were computed from data given in: Hume, H. Harold. The cultivation of citrus fruits. The MacMillan Co., New York, p. 287. 1926; and in: Barnette, R. M., *et al.* The mineral analysis of a nineteen year old Marsh seedless grapefruit tree. The Citrus Industry 12(3):5, 6, 34. 1931.

As shown in table 2, the amount of phosphate removed by an average crop of oranges plus that required for the production of the annual new growth of the tree, is not greatly different from that removed by the cereals, corn, clover, and potatoes. However, annual crops must secure their phosphate in a growing period of from 2 to 4 months, whereas the citrus tree probably absorbs phosphate continuously throughout the year. Therefore, it is probable that the average rate of phosphate absorption by citrus is not nearly so rapid as with the annuals. This suggests that citrus trees may be able to satisfy their phosphate requirement from soils containing lower total supplies of available phosphate than is necessary for quick-growing plants.

The results of certain pot-culture and field fertilizer trials, briefly described in the following sections, support this theory.

Pot-Culture Studies.—Following the growth and harvest of alfalfa in a series of differentially fertilized soils, very young sweet-orange seedlings were transplanted into the same pots and allowed to grow until they had attained a growth roughly corresponding to that made by the alfalfa. The relative responses of the alfalfa and citrus to phosphate

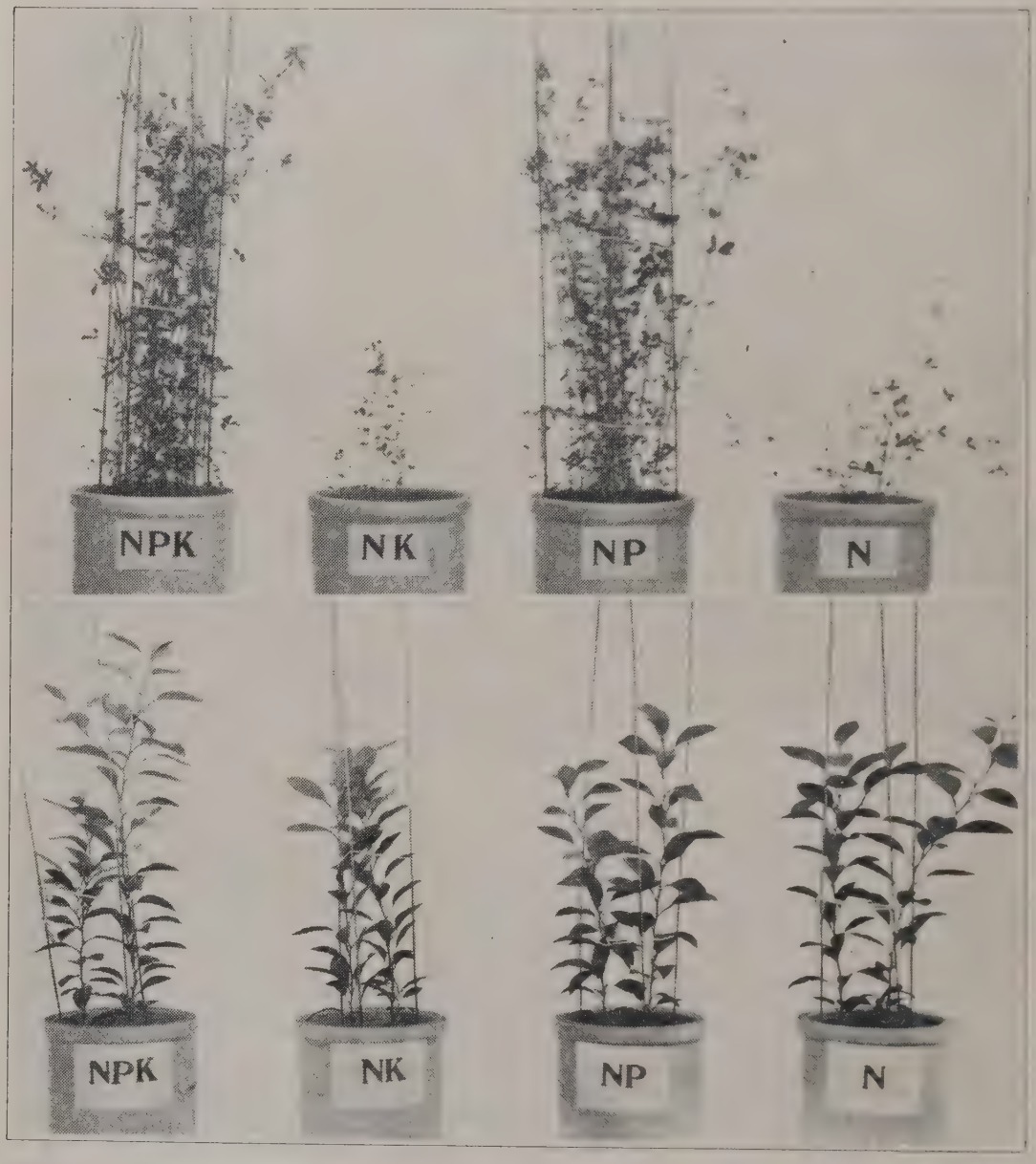


Fig. 1.—Relative response of alfalfa and citrus seedlings to phosphate additions. Soil No. 18053, Hanford sand from Santa Ana.

additions in these various soils is shown by the illustrations in figures 1, 2, and 3. Soils 18053 and 18064 are markedly deficient in phosphate for alfalfa, as is shown by the growth increases resulting from phosphate additions. These are calcareous types, and illustrate some of the most extreme cases of phosphate deficiency found in any of the soils studied. On the other hand, citrus seedlings growing in these same soils showed

no effect whatever from the addition of phosphate, indicating that for these plants the original soil supply is apparently ample. For purposes of comparison the results on another soil showing no evidence of phosphate deficiency for alfalfa is also included (fig. 3).



Fig. 2.—Relative response of alfalfa and citrus seedlings to phosphate additions. Soil No. 18064, Yolo loam from Tustin.

Field Trials.—Three of the field trials with citrus, the results of which are briefly reviewed later in this paper, were located on soils of low phosphate availability (table 5, Orange County Farm, Santa Ana; C. C. Chapman orchard, Fullerton; and Chula Vista Experiment). The complete absence of increases in yield from phosphate in these field

trials again suggests that the citrus tree may be able to grow normally on soils which contain an inadequate supply of available phosphate for some quick-growing plants.

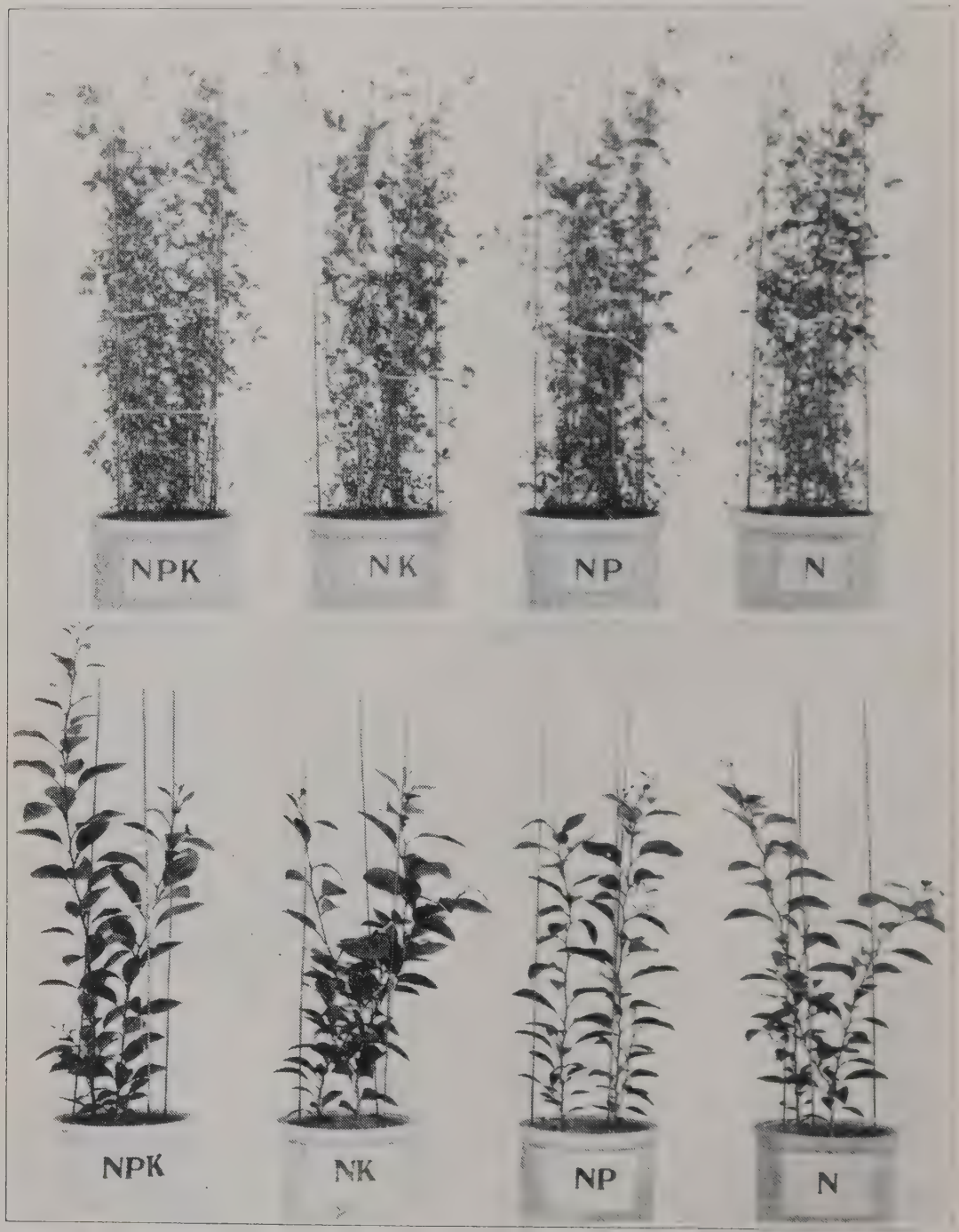


Fig. 3.—Relative response of alfalfa and citrus seedlings to phosphate additions. Soil No. 18058, Yolo clay loam from Santa Paula

In general the aforementioned lines of evidence indicate that, as far as citrus is concerned, the *unfertilized* soils representative of citrus areas contain an adequate supply of available phosphate. It has been shown by the data of table 1, however, that most of the soils of *commercial citrus orchards* contain *more* phosphate now than the adjacent unfer-

tilized types. A portion at least of this accumulated phosphate is accessible to citrus roots and additional evidence indicates that it is more soluble and inferentially more available than that originally present. For example, the data recorded in table 3 show that the acid solubility of the phosphate in orchard soils exceeds that of the contiguous unfertilized types. This difference in solubility is again shown by the increased water solubility of the phosphate of orchard soils as shown in table 1.

TABLE 3

COMPARATIVE SOLUBILITY OF PHOSPHATE IN FERTILIZED AND UNFERTILIZED SOILS

Soil type	Laboratory No.	Treatment	Years fertilized	Total PO_4, parts per million in soil	Acid-soluble PO_4	
					Parts per million in soil	Per cent of total phosphate
Hanford sandy loam	15915	None	....	1,220.0	114.0	9.4
	15917	Fertilized	40	4,820.0	2,580.0	53.5
Hanford gravelly sandy loam	16107	None	....	1,500.0	172.0	11.5
	16110	Fertilized	15	3,760.0	1,280.0	33.0
Hanford loam	15601	None	....	2,250.0	338.0	15.0
	15633	Fertilized	22	3,590.0	966.0	26.9
Ramona loam	15662	None	....	1,460.0	178.0	12.2
	15658	Fertilized	30	2,350.0	880.0	37.5
Placentia loam	15738	None	....	2,350.0	288.0	12.2
	15653	Fertilized	22	4,890.0	2,178.0	44.5
Placentia loam	17400	None	....	1,920.0	196.0	10.2
	17403	Fertilized	35	2,400.0	475.0	19.8
Yolo clay adobe	15714	None	....	1,630.0	560.0	33.3
	15718	Fertilized	18	2,090.0	654.0	31.3
Hanford loam	18036	None	....	2,440.0	207.0	8.5
	15730	Fertilized	14	3,000.0	1,020.0	29.4

Hence, the results of chemical and pot-culture studies indicate that the present supply of phosphate in citrus orchards is ample to meet the needs of the citrus tree. The results of field trials briefly reviewed in the following section offer still further evidence in harmony with this conclusion.

PLOT EXPERIMENTS

The average yields of citrus fruit that have been obtained from those plots of several different fertilizer experiments which bear on the phosphate question are assembled in table 4. The important point brought out by these data is that added phosphate has uniformly failed to increase yields. On the other hand, marked effects have been produced by nitrogen.

TABLE 4

RESULTS OF FIELD FERTILIZER TRIALS WITH CITRUS

Location	Soil type	Fruit	Period represented by yield data and number of years averaged§	Plot	Treatment	Average annual yield per tree, pounds
Rubidoux Plots, Riverside	Sierra loam	Navel and Valencia oranges, Eureka and Lisbon lemons	1912-1932 (Navels, 21-year av.; Valencias, 20-year av.; Eurekas and Lisbons 15-year av.)	B	None	36.9*
				T	None	26.4*
				C	Dried blood	92.2*
				S	Dried blood	94.3*
				Q	Dried blood, sodium nitrate, potassium sulfate, superphosphate	97.7*
Citrus Experiment Station, Field I, Riverside	Ramona loam	Navel oranges	1927-1931 (5 years)	6†	Covercrop	90.2
				18	Urea, covercrop	121.5
				8	Urea, treble superphosphate, covercrop	115.2
				11	Urea, potassium sulfate, covercrop	129.0
				9	Urea, potassium sulfate, treble superphosphate, covercrop	124.2
Chaffey Junior College, Ontario	Hanford stony sandy loam	Navel oranges	1915-1930 (15 years)	4C	Ammonium sulfate	130.5
				3C	Tankage (8-8)	122.0
				2C	Complete (6-8-2)	116.6
				4A	Ammonium sulfate, covercrop	124.1
				3A	Tankage (8-8), covercrop	114.5
				2A	Complete (6-8-2), covercrop	115.7
Fontana Farms, Fontana	Hanford gravelly sand	Navel oranges	1918-1922 (5 years)	2A, 4A, 6A	None	9.0
				1C,3C, 5C, 7C	None	6.5
				1A	Sodium nitrate	31.6
				2C	Sodium nitrate, superphosphate	25.3
				1B	Sodium nitrate, gypsum	35.2
				2D	Sodium nitrate, gypsum, superphosphate	19.9
				4C	Sodium nitrate, potassium sulfate	16.6
				3A	Sodium nitrate, potassium sulfate, superphosphate	16.5
				4D	Sodium nitrate, potassium sulfate, gypsum	24.7
				3B	Sodium nitrate, potassium sulfate, gypsum, superphosphate	32.9
Arlington Heights	Placentia loam	Navel oranges	1916-1920 (5 years)	14B	Covercrop	104.6
				38B	Covercrop	96.8
				41B	Ammonium sulfate, covercrop	141.0
				12B	Dried blood, covercrop	156.0

* Average of both oranges and lemons.

† Treatment No.

§ The apparent discrepancy in some casse between inclusive dates and the years averaged is accounte for by failure to secure yield data in one or more of the years during the period in question.

TABLE 4—*Concluded*

Location	Soil type	Fruit	Period represented by yield data and number of years averaged§	Plot	Treatment	Average annual yield per tree, pounds
Arlington Heights—(*Concluded*)	Placentia loam	Navel oranges	1916-1920 (5 years)	17B	Dried blood, sodium nitrate, potassium sulfate, covercrop	162 8
				39B	Dried blood, sodium nitrate, potassium sulfate, superphosphate, covercrop	125.0
				19B	Dried blood, sodium nitrate, superphosphate, covercrop	145 8
Orange County Farm, Santa Ana	Hanford sandy loam	Valencia oranges	1924-1929 (5 years)	2A, 2B	Dried blood, ammonium sulfate	279.3‡
				3A, 3B	Dried blood, ammonium sulfate, superphosphate	265 2‡
				4A, 4B	Dried blood, ammonium sulfate, potassium sulfate, superphosphate	239.5‡
C. C. Chapman orchard, Fullerton	Hanford loam	Valencia oranges	1924-1931 (7 years)	2A, 2B, 2C	Dried blood, ammonium sulfate	217 2‡
				3A, 3B, 3C	Dried blood, ammonium sulfate, superphosphate	228 4‡
				4A, 4B, 4C	Dried blood, ammonium sulfate, potassium sulfate, superphosphate	222.9‡
Chula Vista	Kimbal sandy loam	Lemons	1915-1920 (5 years)	3	Ammonium sulfate	207.0¶
				4	Dried blood	138.0¶
				2	Complete	138.0¶
Naranjo, Tulare County	San Joaquin loam	Navel oranges	1916-1923 (6 years)	1	Sodium nitrate	93.0
				2	Tankage (8-8)	101.0
				3	Complete (4-10-2)	77.0

‡ Converted from field boxes to pounds using 50 pounds per box.
¶ Converted from field boxes to pounds using 46 pounds per box.
§ The apparent discrepancy in some cases between inclusive dates and the years averaged is accounted for by failure to secure yield data in one or more of the years during the period in question.

The suggestion has often been made that the lack of response to phosphate applications may possibly have been due to the failure of the phosphate to penetrate into the root zone of the soil. As bearing on this question, soil samples taken from a number of the phosphate plots of these experiments and from plots to which no phosphate has been applied, have been investigated. Determinations were made of water-soluble and dilute acid-soluble phosphate. The data reported in table 5 show that in all cases the applied phosphate has penetrated, to some extent at least, into the root zone. In the case of the experiments of longest duration, namely, the Rubidoux, Chaffey, and Fontana trials, the penetration of the phosphate has been very striking.

TABLE 5

PHOSPHATE PENETRATION IN SOILS OF FIELD PLOTS

Location	Soil type	Date fertilization was begun	Date of sampling	Plot	Treatment	Water-soluble				Acid-soluble			
						0–6 inches	6–12 inches	12–24 inches	24–36 inches	0–6 inches	6–12 inches	12–24 inches	24–36 inches
						Parts per million PO_4 in dry soil							
Rubidoux Plots, Riverside	Sierra loam	1907	1930	B	None	5.7	3.6	2.9	5.7	370	342	430	496
				T	None	4.6	3.6	3.6	2 3	288	276	300	386
				S	Dried blood	6.1	0 8	3 5	4.0	474	344	420	556
				Q	Dried blood, sodium nitrate, potassium sulfate, superphosphate	30.5	33.0	26.7	8.6	2,178	1,320	548	378
Citrus Experiment Station, Field I, Riverside	Ramona loam	1927	1930	L14	None	10 2	5.3	2.8	2.3	130	172	162	336
				M6	Urea	11.7	5.3	2.2	1.5	122	118	116	356
				L16	Urea, superphosphate	19.3	13.2	3.7	0.9	224	214	147	282
				M16	Urea, potassium sulfate, superphosphate	20.3	9.8	2.9	2.1	226	156	136	334
			1932	H32	Covercrop	8.1	5.5	4.5	4.6	167	139	153	347
				M12	Urea, covercrop	3.2	2.4	4.6	4.5	167	142	142	278
				L20	Urea, covercrop superphosphate	28.8	23.0	8.7	4.6	406	259	170	245
Chaffey Experiments, Ontario	Hanford stony sandy loam	1915	1930	4C	Ammonium sulfate	13.0	3.4	4.6	2.7	266	152	194	156
				2C	Complete (6-8-2)	36.2	44.2	27.9	32.0	880	662	342	316
Fontana Farms, Fontana	Hanford gravelly sand	1912	1930	6A	None	9.7	8.9	8.1	.....	172	178	186	.....
				2C	Sodium nitrate, garbage manure,* superphosphate	133.4	38.1	29.1	29.0†	1,280	434	308	308
Orange County Farm, Santa Ana	Hanford sandy loam	1924	1930	2A	Dried blood, ammonium sulfate	1.5	0.5	Trace	Trace	262	232	96	44
				3A	Dried blood, ammonium sulfate, superphosphate	6.9	1.9	Trace	Trace	620	392	148	70
				2A	Dried blood, ammonium								

Although certain criticisms may be made of some of these plot experiments there is no plausible explanation of the uniform failure of phosphate to give increases in yield, other than that the soils of these experimental areas already contained an adequate amount of available phosphate. These experiments were well distributed as to locality and soil type, and since the chemical studies show that the amount and availability of the phosphate in the various commercial orchards is now *higher* than in many of the soils of these orchards under experiment, there can be but little reasonable ground for doubt about the general application of these field results.

As has been pointed out, the unfertilized soils representative of certain types or areas are somewhat low in phosphate. It is conceivable that of these, some may be found in which the supply or availability of phosphate is inadequate for covercrops. In cases where covercrops fail to grow normally, tests[6] with phosphate should be made.

SUMMARY

Chemical and pot-culture studies have shown that most of the unfertilized soils in the principal citrus areas of southern California are well supplied with phosphate and that, with the exception of the calcareous types of soil, the phosphate is in a readily available state.

Chemical studies have further shown that citrus-orchard soils of California have made substantial gains in phosphate as a result of past fertilization practices and that this phosphate is more soluble than the phosphate of the unfertilized soils.

The results of fertilizer trials in pot cultures, and in certain fields, and a consideration of the amounts of phosphate annually absorbed by citrus trees as compared with that of quick-growing crops, leads to the conclusion that citrus trees may be able to secure ample phosphate from less available forms and lower total supplies than certain annual crops.

The use of phosphate or phosphorus containing materials in 9 different field trials with citrus, for periods ranging from 5 to 20 years, has in no case resulted in significant increases in the yields of fruit. Chemical studies indicate that the applied phosphate has penetrated into the root zone.

[6] In citrus orchards where adequate provisions are made for the maintenance of nitrogen, this test can be carried out as follows: Select several representative areas about 15 feet square between the tree rows in various parts of the orchard. Prior to seeding the covercrop, broadcast and work into the surface soil about 10 pounds of 20 per cent superphosphate. Observe from time to time the growth of the covercrop on this as compared to adjacent untreated areas. The results should reveal whether or not phosphate is needed.

Based on the above lines of evidence, it is concluded that, in so far as citrus trees are concerned, the majority of the soils of commercial citrus orchards in California contain at present an ample supply of available phosphate.

It is possible that covercrops, when grown in citrus orchards that are located on calcareous types of soil or on those relatively low in phosphate, will be benefited by applications of phosphate. In cases where satisfactory growth of covercrops has not been obtained, tests with phosphate should be made.

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BERKELEY, CALIFORNIA

IRRIGATION EXPERIMENTS WITH PRUNES

A. H. HENDRICKSON AND F. J. VEIHMEYER

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IRRIGATION EXPERIMENTS WITH PRUNES[1]

A. H. HENDRICKSON[2] AND F. J. VEIHMEYER[3]

INTRODUCTION

THIS REPORT is one of a series on the water relations of fruit trees, and includes the measuring of certain responses of prune trees and fruit to different irrigation treatments in an orchard at Davis during 10 years, 1923 to 1933. The experiments described constituted a further inquiry into the question of whether measurable differences in plant responses are obtained with varying moisture contents between the field capacity and the permanent wilting percentage. Previous reports have dealt with peaches, prunes, and grapes.[1, 2, 4][4] The experiments were conducted under interior valley conditions, with temperatures sometimes reaching 110° Fahrenheit in the summer, and 25° F in December and January. The annual rainfall for the 10 years averaged 14.7 inches. Under typical summer conditions, the evaporation from a standard class A United States Weather Bureau Station pan sometimes reached 0.5 inch per day; the daily loss from a standard white atmometer, sometimes 175 cc. Where water is available, irrigation of orchards in this region is generally practiced.

THE ORCHARD AND THE CULTURAL METHODS USED

The experimental orchard covers 3.2 acres. Planted in 1917 with carefully selected one-year-old nursery stock, it consists of 13 rows of 15 trees each of Agen (French) prune on myrobalan rootstock.

During the first six years, all trees were treated as nearly uniformly as possible. Pruning, during the first few years, was essentially a training process, designed to provide a strong system of framework branches. Thereafter it consisted of a light annual thinning, to prevent crowding of branches in later years. Throughout, the pruning has been relatively light, with no innovations that might change the bearing or growth habits. After the preliminary training period, the trees assumed their natural shape. Figures 1 and 2 show a typical tree at successive stages of growth.

[1] Received for publication April 4, 1934.

[2] Pomologist in the Experiment Station.

[3] Associate Professor of Irrigation Investigations and Practice, and Irrigation Engineer in the Experiment Station.

[4] Superscript numbers in parentheses refer to "Literature Cited" at the back of the bulletin.



Fig. 1.—A typical French prune tree at Davis: *A*, at 2 years of age; *B*, at 3 years; *C*, at 4 years; and *D*, at 7 years.

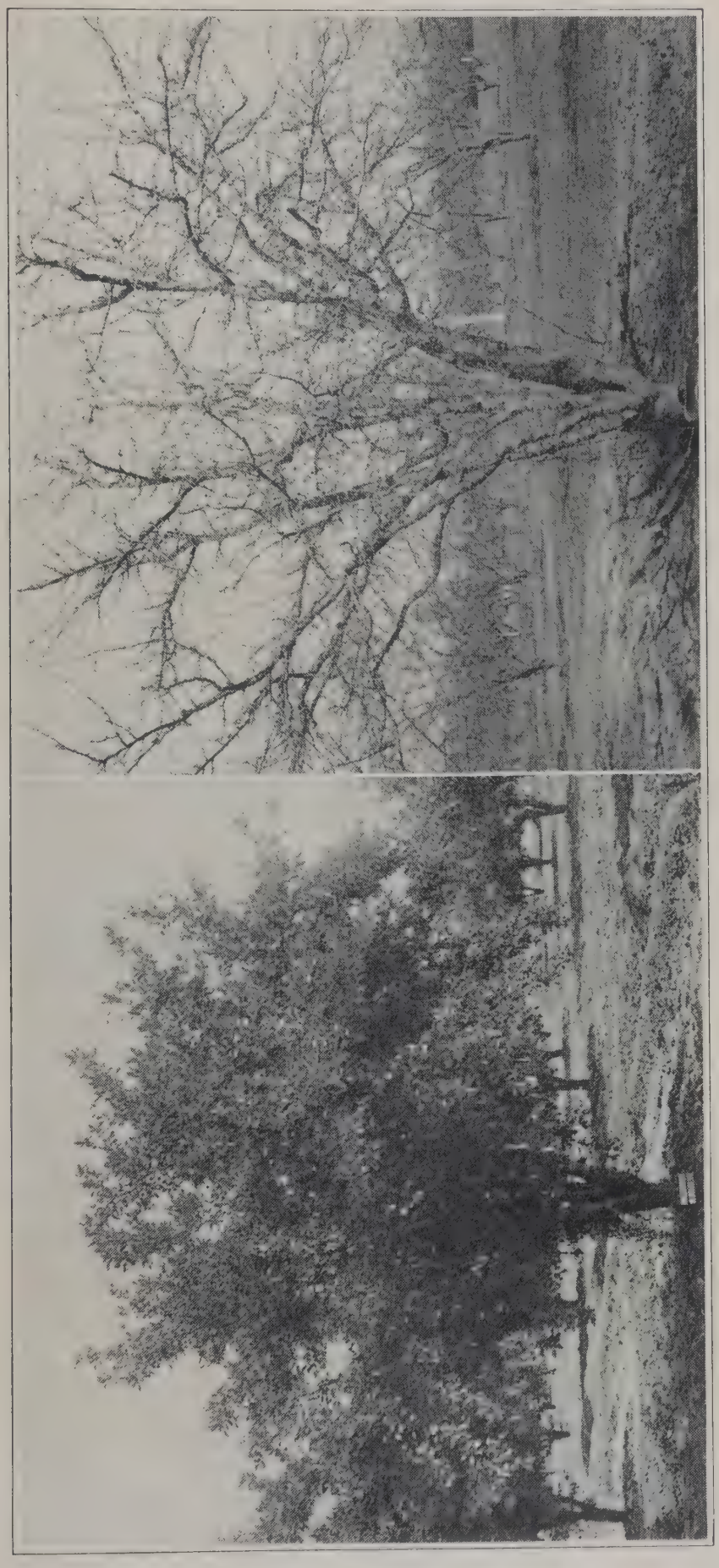


Fig. 2.—The same tree as shown in figure 1: left, during the summer of the sixteenth year; and right, in the following winter.

All trees have been sprayed each summer, chiefly to control aphids and red spiders, but no winter sprayings have yet been necessary. Though satisfactory control was usually secured, the crop was materially affected by red spiders one year, as will be described later.



Fig. 3.—Method of irrigation used in the experimental orchard. Photographed October 5, 1923.

The usual practice was to disk the native weeds in March and not to cultivate again before the first irrigation, unless numerous weeds appeared. After the March cultivation, the soil in the unirrigated plots was left untouched, except to smooth it just before harvest. Whenever irrigation was necessary on certain plots, ridges were thrown up, enclosing each tree in a square basin (fig. 3). After irrigation, the ridges were cultivated lightly to fill the cracks through which leaks might occur next time, but the remaining soil was undisturbed. Thus, the basins were used two or three times without being torn down and remade. Shortly before harvest the entire orchard was cultivated and smoothed to facilitate picking. Plots that subsequently received no water were not cultivated further. On those irrigated after harvest, the ridges were

plowed down to facilitate winter pruning and brush-burning. Neither covercrops nor fertilizers were used.

The soil is classified as a Yolo loam. Below 3 feet, layers of sand or fine gravel are sometimes encountered. No outstanding differences in tree behavior were caused by the varying soil texture. Before the orchard was planted, the area had produced small grains and alfalfa; but no fertilizers had been added for at least seven years before the trees were set out.

OUTLINE OF THE EXPERIMENT

Obviously, with comparatively few trees available, the different treatments must be few, and the number of replications limited. Each experimental row of trees was completely surrounded by guard trees receiving the same irrigation treatment. In other words, somewhat less than one-third of all trees were available for close study. After careful consideration, the plots were laid out as shown in figure 4.

The plots for the different treatments were selected according to the growth measurements of the trees for the first 6 years after planting. During this time, all trees were kept as healthy and vigorous as possible. At first the length of the new shoots was measured with a centimeter rule, and the circumference of the trunk about 6 inches above the bud union was measured with a steel tape. After the trees were several years old, however, the large number of new shoots made the length measurement impracticable, so that after 1920 the trunk measurement was used as the sole index to growth.[5] The coefficients of correlations between length growth of new shoots and cross-section area of the trunks, as expressed statistically, were 0.74 ± 0.026 in 1919, and 0.71 ± 0.025 in 1920.

In grouping the plots for the various treatments, plots of high variability in size were placed with those of low variability. The coefficients of variability based on the cross-section area of the tree trunks, after 6 years of uniform care and before differential treatments began, are shown in table 1. The treatments are designated by letters as explained later. A plan of the orchard is shown in figure 4.

The irrigation treatments consisted in wetting the soil by the basin method, to eliminate the dry portions which, in furrow irrigation, usually hamper the interpretation of soil-moisture data (fig. 3). The time of applying water was determined by studying the soil-moisture samples taken regularly with a soil tube in each plot. The amount of water to be applied was calculated from the volume weight, the mois-

[5] Trunk circumferences of old trees may not be such reliable measurements of the fruit-producing portion of a tree as with young trees. Because of the difficulties involved in other methods, however, they are ordinarily used.

ture equivalent, and the water in the soil, and was measured over a weir. Soil samples were taken during the growing season in 3-foot increments to a depth of 6 feet at frequent intervals, at five places in each plot, and in certain years to a depth of 12 feet about once a month.

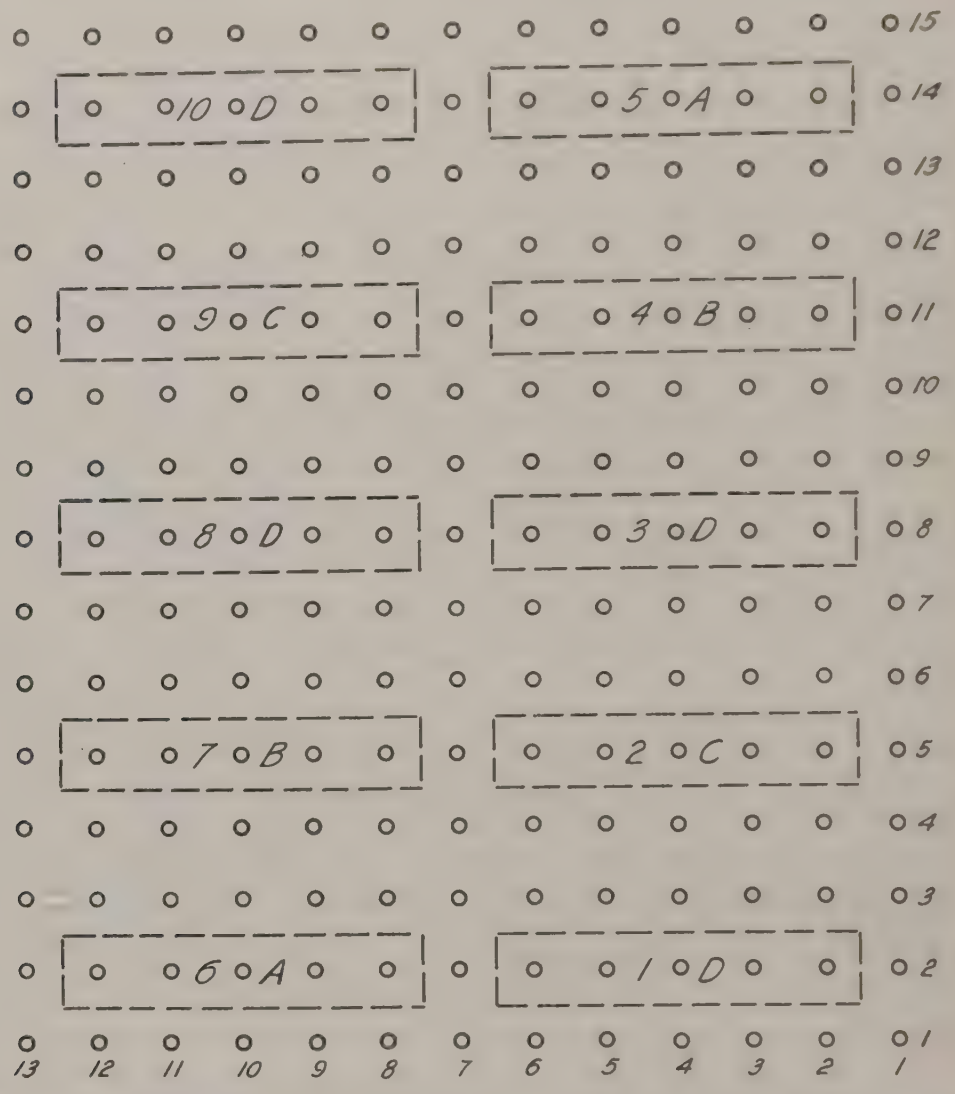


Fig. 4.—French-prune orchard at Davis, showing location of plots. The experimental trees are inclosed in the broken lines.

The plan of irrigation for each treatment is given below:

Treatment A.—The plots were kept supplied with readily available water.[6] This will be sometimes referred to as the "continuously moist" treatment."

Treatment B.—The plots were irrigated before, but not after July 1.

Treatment C.—The trees were not irrigated until after July 1.

Treatment D.—No water was added to the soil during the growing season.

[6] For definition of this term, see page 10.

The general plan was to have one treatment with continuously moist soil; one with moist soil early in the season, but with dry soil later; one with dry soil for a short time about midsummer, but with moist soil later; and one not irrigated during the growing season. Water was applied to meet these requirements as closely as possible. Because of the small size of the trees, the plan was not completely carried out during the early years; but, in 1926 and thereafter, the readily available moisture was exhausted at about the desired time.

This report gives the results of the experiments over a 10-year period, and may be considered a progress report. The experiments are being continued.

TABLE 1

Coefficients of Variability in Sizes of Prune Trees at Davis, California, from Cross-Section Areas of Trunks, in December, 1922

Treatment	Plot	Coefficient of variability	Treatment	Plot	Coefficient of variability
		per cent			*per cent*
D	1	8.6±1.8	A	6	7.4±1.6
C	2	12.7±2.7	B	7	6.4±1.4
D	3	10.2±2.2	D	8	7.0±1.5
B	4	16.0±3.4	C	9	3.2±0.7
A	5	11.1±2.4	D	10	7.3±1.6

PROCEDURE AND EXPERIMENTAL RESULTS

The data given in this bulletin were obtained from the following sources: soil-moisture characteristics; measured quantities of water applied to the various plots; soil-moisture determinations from samples obtained with soil tubes; annual measurements of tree growth and yields; growth measurements of the fruit; sugar and acid contents of the fresh fruit; drying ratios; specific gravity determinations; and segregations of fruit sizes after drying. The time of blossom-opening and of fruit-ripening, any injury by insect infestation, and the general condition of the trees were observed.

Moisture Properties of the Soil.—As shown by previous work with prunes,[4] certain soil-moisture conditions are important. Since the terms describing them will be used frequently, they must be briefly defined. The *moisture equivalent* is a laboratory determination of the water-holding capacity of soil under certain conditions. In fine-textured soils it is a fair measure of the field capacity[6]—that is, the amount of water retained after the excess has drained away and after the rate of downward movement has materially decreased. This moisture condition prevails in pervious soils 2 or 3 days after a rain or an irrigation. The *permanent wilting percentage* is that soil-moisture content at which

plants wilt and do not recover unless water is added to the soil. The term "readily available moisture" is applied to the range of moisture between the field capacity and about the permanent wilting percentage, since previous investigations[1] by the writers have shown no differences in the rate of soil-moisture extraction within this range. Trees may obtain some water from a soil below the permanent wilting percentage, but not enough to prevent wilting. Water-holding characteristics of soils are described more fully in Extension Circular 50.[7]

Previous work[4] shows that soil moisture could fluctuate between wide limits without affecting orchard trees. The experiment was planned, therefore, to allow the trees in certain treatments to reduce the soil moisture to the lower limit instead of applying stated quantities of water at definite intervals. At the start, in 1923, this lower limit was generally believed to be the "wilting coefficient," obtained by dividing the moisture equivalent by the factor 1.84. This wilting coefficient was used for several years to measure the limit below which the trees would not extract moisture readily. As was shown later,[5] however, it does not always agree with the soil-moisture content at which plants wilt; and the permanent wilting percentage does not bear a constant relation to the moisture equivalent, but must be determined for each soil by observing the plants in the field, by growing indicator plants in containers, or by studying the soil-moisture extraction curves.

The permanent wilting percentages used were obtained from the points on the soil-moisture extraction curves that indicated a markedly reduced rate of extraction, and from growing and wilting sunflower plants on composite samples of the various depths obtained from each plot. Though the "wilting coefficients" used early in the experiment differed from the permanent wilting percentages, these differences were soon discovered and did not affect the experimental results.

Table 2 gives certain soil-moisture characteristics. The moisture equivalents varied considerably at the different depths sampled. In general, the 3 to 6-foot depth has an average moisture equivalent considerably lower than that in the other depths.

Although the soil in the experimental area proved to be fairly uniform, individual moisture equivalents and permanent wilting percentages varied widely from the average. Similar variations are ordinarily encountered and must be considered in interpreting experimental data.

Using a small number of determinations is somewhat hazardous when the results will be applied to the whole area. In the present experiment the moisture equivalents were obtained from hundreds of samples; and the moisture curves, shown later, are also averages of many determinations for soil-moisture content. Obviously, the moisture equivalents and

permanent wilting percentages from one corner of a field would probably not agree exactly with those from the opposite corner, even in a soil apparently as uniform as the one used. Individual determinations of the moisture equivalent varied from the averages given, possibly because of the undulating layers of different-textured soil beneath the surface. The extreme variation of the moisture equivalent at a given depth ranged from about 3.5 per cent below to about 4.0 per cent above the average.

TABLE 2

MOISTURE EQUIVALENTS AND PERMANENT WILTING PERCENTAGES OF SOIL IN EXPERIMENTAL PLOTS

Depth of soil, feet	Moisture equivalent	Permanent wilting percentage	Depth of soil, feet	Moisture equivalent	Permanent wilting percentage
Treatment A			Treatment C		
0 to 3	20.1	9.9	0 to 3	20.2	9.8
3 to 6	16.4	8.4	3 to 6	14.5	8.0
6 to 9	20.9	9.0	6 to 9	21.2	9.4
9 to 12	23.9	8.7	9 to 12	24.0	10.7
Treatment B			Treatment D		
0 to 3	21.0	9.9	0 to 3	21.4	9.8
3 to 6	14.2	8.4	3 to 6	15.1	7.8
6 to 9	18 3	8.9	6 to 9	17.8	10.6
9 to 12	20.2	9.5	9 to 12	20.8	10.3

Irrigation of the Plots.—The amounts of water applied to the different plots are given in table 3. Because of the low rainfall in the winters of 1928–29 and 1930–31, as shown in table 4, all plots were sufficiently irrigated in late winter to insure having the soil wet to a depth of 6 feet at the beginning of the growing season. The amount of water applied at this time is not included in the totals in table 3.

The trees in treatment A received the most water except in 1932, when one plot in C received more than did one in A. In general, the plots, in A received two or three irrigations during the growing season until 1929, and four irrigations in 1929 and thereafter. One irrigation each year was applied after harvesting. The more frequent irrigations toward the end of the 10-year period were necessitated by the increased tree size. The soil moisture in these plots was maintained above the permanent wilting percentage throughout the year.

The trees in treatment B were irrigated once annually from 1923 to 1928, inclusive, and in 1932; and twice each year in 1929, 1930, and 1931. The irrigations were applied before July 1 each year. The average application of water to treatment B was less than that given to C.

TABLE 3

WATER APPLIED TO ORCHARD IN ACRE-INCHES PER ACRE

Date	Treatment A		Treatment B		Treatment C	
	Plot 5	Plot 6	Plot 4	Plot 7	Plot 2	Plot 9
1923						
May 19-22	3.6	5.3	5.1	5.9	0.0	0.0
July 20-24	6.0	4.8	0.0	0.0	6.4	6.4
Oct. 5- 8	4.1	4.4	0.0	0.0	4.9	4.5
Total	13.7	14.5	5.1	5.9	11.3	10.9
1924						
June 10-13	4.8	4.9	6.6	5.3	0.0	0.0
Sept. 12-13	5.5	6.3	0.0	0.0	6.6	7.0
Total	10.3	11.2	6.6	5.3	6.6	7.0
1925						
June 25-26	3.8	3.5	3.7	2.8	0.0	0.0
July 28-30	0.0	0.0	0.0	0.0	7.5	3.9
Aug. 14	5.0	4.5	0.0	0.0	0.0	0.0
Oct. 5- 6	3.0	3.0	0.0	0.0	3.0	3.0
Total	11.8	11.0	3.7	2.8	10.5	6.9
1926						
June 18-20	5.5	5.6	5.6	5.1	0.0	0.0
July 24	0.0	0.0	0.0	0.0	5.0	5.0
Aug. 27-28	6.8	6.6	0.0	0.0	4.9	3.7
Total	12.3	12.2	5.6	5.1	9.9	8.7
1927						
June 9-10	5.0	5.2	3.6	3.7	0.0	0.0
July 15	4.7	4.3	0.0	0.0	7.0	7.2
Oct. 4	4.0	4.0	0.0	0.0	4.0	4.0
Total	13.7	13.5	3.6	3.7	11.0	11.2
1928						
June 22-25	10.1	10.1	10.1	10.1	0.0	0.0
July 18-20	0.0	0.0	0.0	0.0	9.5	9.5
July 31	4.0	4.0	0.0	0.0	0.0	0.0
Sept. 27-28	6.0	6.0	0.0	0.0	6.0	6.0
Total	20.1	20.1	10.1	10.1	15.5	15.5
1929						
May 17-18	5.8	7.1	5.8	5.8	0.0	0.0
June 24-25	4.8	4.8	4.8	4.8	0.0	0.0
July 26-29	5.1	5.1	0.0	0.0	8.6	8.6
Sept. 30-Oct. 1	5.3	5.3	0.0	0.0	5.3	5.3
Total	21.0	22.3	10.6	10.6	13.9	13.9
1930						
May 23-24	7.2	7.2	7.2	7.2	0.0	0.0
June 26-27	5.6	5.6	5.6	5.6	0.0	0.0
July 17	0.0	0.0	0.0	0.0	7.0	7.0
July 31	6.0	6.0	0.0	0.0	0.0	0.0
Sept. 22-24	6.6	6.6	0.0	0.0	6.6	6.6
Total	25.4	25.4	12.8	12.8	13.6	13.6
1931						
June 2-3	8.0	8.0	8.0	8.0	0.0	0.0
June 25	5.6	5.6	5.6	5.6	0.0	0.0
July 16	0.0	0.0	0.0	0.0	11.9	11.9
July 27	8.0	8.0	0.0	0.0	0.0	0.0
Sept. 2-4	8.9	8.9	0.0	0.0	8.9	8.9
Total	30.5	30.5	13.6	13.6	20.8	20.8
1932						
June 17-18	7.3	7.7	7.3	7.7	0.0	0.0
July 11-12	4.8	7.5	0.0	0.0	8.8	12.5
Aug. 10-11	8.0	8.1	0.0	0.0	7.5	8.1
Sept. 23-24	5.9	5.9	0.0	0.0	6.3	6.5
Total	26.0	29.2	7.3	7.7	22.6	27.1

The trees in C were not irrigated before July 1. In 1924 it received no irrigation; in 1932, two irrigations; and in the other years, one irrigation before harvesting. In addition, these trees were irrigated each year after harvesting. In general, treatment C received less water than A, but more than B. Throughout the experiment, no water was applied to the trees in D in the growing season; but this treatment received a late winter irrigation in 1929 and in 1931, because of deficient rainfall.

TABLE 4

RAINFALL AT DAVIS, IN INCHES

Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Total
1922-23	0.00	0.00	0.00	1.56	3.29	7.37	2.62	0.70	0.00	2.22	0.10	0.00	17.86
1923-24	0.00	0.00	0.35	0.40	0.53	0.88	2.46	2.76	1.18	0.38	0.05	0.00	8.99
1924-25	0.00	0.00	0.00	2.05	1.42	3.55	1.05	4.28	3.10	2.15	1.63	0.02	19.25
1925-26	0.00	0.03	0.10	0.01	1.71	1.29	3.70	5.50	0.01	5.74	0.26	0.00	18.35
1926-27	0.00	0.01	0.00	2.01	5.18	0.73	2.18	4.66	1.07	2.48	0.31	0.47	19.10
1927-28	0.00	0.00	0.00	1.71	2.91	2.32	1.73	1.62	3.45	0.75	0.27	0.00	14.76
1928-29	0.00	0.00	0.00	0.13	3.19	2.74	0.63	1.56	1.34	0.34	0.01	0.94	10.88
1929-30	0.00	0.00	0.00	0.09	0.00	3.77	3.80	1.66	3.48	0.92	0.18	0.00	13.90
1930-31	0.00	0.00	0.23	0.69	0.92	0.20	3.71	1.02	0.85	0.00	0.80	0.31	8.73
1931-32	0.00	0.00	0.00	0.17	1.36	7.84	1.35	1.67	2.01	0.66	0.15	0.00	15.21
Mean	0.00	0.004	0.07	0.88	2.05	3.07	2.33	2.54	1.65	1.56	0.38	0.17	14.70

Soil-Moisture Conditions.—The soil-moisture records are given in tables 5 and 6. For 1928, 1930, and 1932, they are also shown graphically in figures 5, 6, 7, and 8. They are typical of records obtained during the last half of the experiment. The downward slopes from left to right show how fast the trees used water, while the sharp upward slopes indicate when irrigation water was applied.

In treatment A, according to the soil-moisture records, the moisture content, except for a brief period in late September, 1927, was maintained above the permanent wilting percentage in the top 6 feet throughout the study. During the last half of the experiment, there was available water in the 6 to 9-foot depth, and during the last 3 years, in the 9 to 12-foot depth also. Occasional samples indicated available moisture at all times in the 6 to 12-foot depth during the early years of the experiment. In general, water was used more rapidly from the 0 to 3 than from the 3 to 6-foot depth, and more rapidly from both these than from the 6 to 9 and the 9 to 12-foot depths.

In treatment B the trees were supplied with available soil moisture until late summer. Even though these plots received no irrigation after July 1, the permanent wilting percentage was not reached in the latter part of the season in the top 6 feet of soil until 1926, when it was reached late in September. The permanent wilting percentage was reached in the

upper 6 feet on the following approximate dates: August 19, 1927; August 28, 1928; August 23, 1929; August 20, 1930; September 15, 1931; and August 9, 1932. In addition, it was almost reached in the 6 to 9-foot depth late in the season in the years 1927 to 1932, with the

TABLE 5

AVERAGE SOIL-MOISTURE PERCENTAGES; 1923 TO 1926, INCLUSIVE

Date	Treatment A		Treatment B		Treatment C		Treatment D	
	0-3 ft.	3-6 ft.	0-3 ft.	3-6 ft.	0-3 ft.	3-6 ft.	0-3 ft.	3-6 ft.
1923								
May 11	15.1	15.5	14.7	13.6	14.9	14.8	15.5	14.3
May 26	20.1	16.2	20.3	16.0	.....	.....	.....	.....
July 3	14.3	14.0	14.7	12.6	11.9	11.3	12.5	11.8
July 27	19.1	15.4	.....	.....	20.6	15.9	.....	.....
Sept. 5	15.5	15.3	11.4	11.4	17.8	15.7	10.2	10.1
Oct. 1	14.7	14.7	.....	.....	14.0	13.2	.....	.....
Oct. 8	20.9	17.7	.....	.....	23.3	16.5	.....	.....
Dec. 4	18.5	18.1	11.8	11.7	17.8	15.7	10.6	9.7
1924								
April 1	16.6	16.5	15.5	11.2	16.7	16.6	15.6	9.4
May 29	13.2	14.1	12.3	11.3	12.5	12.1	12.4	10.0
June 17	18.4	14.6	18.8	12.5	.....	.....	.....	.....
July 30	13.7	13.7	14.6	12.5	11.5	12.4	11.2	9.9
Sept. 2	12.2	12.9	12.3	11.1	10.9	11.6	9.7	9.4
Sept. 16	21.4	15.9	.....	.....	21.6	13.2	.....	.....
Nov. 21	17.7	15.0	14.3	10.5	16.7	12.8	13.1	9.5
1925								
April 7	22.3	18.8	22.8	18.8	22.8	17.9	22.8	15.5
May 28	15.4	15.5	15.8	14.7	15.5	15.0	15.7	14.7
June 16	14.3	15.6	14.8	14.2	.....	.....	.....	.....
July 16	15.3	14.3	15.7	13.4	13.4	10.9	11.4	11.8
Aug. 3	14.3	13.1	.....	.....	19.2	15.4	.....	.....
Aug. 19	20.4	16.8	.....	.....	.....	.....	.....	.....
Sept. 9	17.6	16.4	13.6	12.5	15.6	13.5	11.4	11.4
Oct. 9	18.7	14.8	.....	.....	19.4	12.3	.....	.....
Oct. 30	17.5	14.2	12.4	10.8	18.0	12.4	10.5	10.1
1926								
Mar. 16	18.5	18.1	18.6	17.2	17.8	17.6	18.4	17.5
May 4	17.9	17.2	17.9	16.7	17.7	16.2	18.1	15.7
June 14	13.2	12.7	12.9	12.6	12.7	12.3	13.2	12.5
June 23	20.4	16.8	22.6	17.4	.....	.....	.....	.....
July 23	13.5	12.5	13.5	12.0	10.6	9.3	10.0	9.6
Aug. 19	12.3	11.0	11.5	10.2	16.8	13.8	10.0	9.8
Sept. 1	20.8	16.8	.....	.....	20.6	13.2	.....	.....
Sept. 29	15.3	13.4	10.3	9.3	14.7	11.6	9.5	9.1

exception of 1930. The 9 to 12-foot depth, however, contained some readily available water throughout the last 3 years of the experiment and probably, therefore, during the other years as well. From 1927 to 1932, inclusive, the trees were permanently wilted from one to three weeks before harvesting.

TABLE 6

Average Soil-Moisture Percentages; 1927 to 1932, Inclusive

Date	Treatment A				Treatment B				Treatment C				Treatment D			
	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.
1927																
April 19	19.2	17.2	21.9	.....	20.0	16.8	15.6	.....	19.2	16.0	21.0	.....	20.3	15.6	14.6	.....
May 10	16.2	15.5	20.8	.....	17.2	15.7	16.1	.....	16.7	15.1	20.7	.....	18.3	15.3	14.1	.....
June 2	12.9	13.8	19.5	.....	14.4	14.4	15.3	.....	13.3	12.8	19.1	.....	14.2	13.3	14.4	.....
June 13	22.0	18.8	24.2	.....	20.6	16.6	20.4	.....	.....	.....	.....	.....	.....	.....	.....	.....
June 21	17.9	16.1	22.8	.....	16.7	14.6	18.4	.....	12.0	10.6	18.7	.....	12.7	11.1	13.9	.....
July 7	14.0	13.9	20.3	.....	13.8	12.3	16.6	.....	11.2	10.0	16 6	.....	11.0	10.4	13.2	.....
July 20	19.5	16.4	22.7	.....	11.4	10.7	15.8	.....	20.7	17.2	22.5	.....	10.5	9.3	13.5	.....
Aug. 19	12.4	11.8	16.6	.....	10.0	9.3	12.7	.....	12.8	11.6	17.6	.....	9.8	8.8	12.4	.....
Sept. 30	9.6	9.0	11.2	.....	9.1	8.6	10.4	.....	10.1	9.2	14.1	.....	8.8	8.3	11.3	.....
Oct. 12	16.7	12.0	14.4	.....	.....	.....	.....	.....	17.6	13.3	16.5	.....	.....	.....	.....	.....
1928																
April 13	18.8	15.8	14.6	.....	20.1	11.6	11.2	.....	19.1	15.7	16.2	.....	19.2	12.0	11.6	.....
May 15	14.9	14.8	14.8	.....	14.9	10.7	11.5	.....	15.2	14.0	15 9	.....	15.1	10.8	11.4	.....
June 20	11.2	10.1	13.5	.....	10.9	9.4	10.8	.....	11.6	10.7	15.1	.....	11.3	9.4	11.2	.....
June 28	21.7	16.2	21.0	.....	22.7	16.7	17.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 17	15.1	14.8	19.0	.....	15.1	13.0	16.8	.....	10.0	9.1	12.9	.....	10.2	8.3	10.5	.....
July 26	13.3	12.3	18.2	.....	.....	.....	.....	.....	19.3	15 4	22.5	.....	.....	.....	.....	.....
Aug. 4	20.7	19.3	20.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 28	14 3	12.3	18.6	.....	9 8	8.9	12.7	.....	13.2	11.1	17.3	.....	9.1	8.2	11.0	.....
Sept. 24	10.6	10.1	13 6	.....	9.0	8.2	10.2	.....	9.9	9.8	12.7	.....	8.4	7.9	9.7	.....
Oct. 10	18.1	15.8	21.2	.....	.....	.....	.....	.....	17.8	15.2	21.4	.....	.....	.....	.....	.....
1929																
Mar. 28	17.4	14.3	17.2	.....	17.0	10.2	11.1	.....	17.2	14.6	16.0	.....	16.4	9.7	12.8	.....
April 19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.4	16.6	15.0	.....
May 15	13.6	14.0	17.2	.....	12.9	9.4	10.6	.....	13.3	13.3	15.8	.....	17.1	13.8	14.5	.....
May 24	22.5	17.4	21.9	.....	20.4	16.2	13.4	.....	.....	.....	.....	.....	.....	.....	.....	.....
June 3	17.0	15.8	21.2	.....	16.6	13.9	13.3	.....	11.8	10.6	15.2	.....	14.1	12.5	13.3	.....
June 19	15.5	15.6	19.6	.....	14.8	10.8	13 4	.....	11.6	9.8	14.6	.....	13.4	11.0	13.2	.....
June 29	21.2	19.3	23.7	.....	20.6	16.2	20.8	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 22	13.2	12.7	20.4	.....	12.6	12.2	17.5	.....	9.3	8.4	11.7	.....	10.2	8.6	11.3	.....

TABLE 6—*(Continued)*

Date	Treatment A				Treatment B				Treatment C				Treatment D			
	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.
1929																
Aug. 5	19.9	14.0	18.8	.....	.....	.....	.....	.....	20.4	16.7	22.2	.....	.....	.....	.....	.....
Aug. 23	14.0	11.0	15.4	.....	9.9	9.0	12.6	.....	14.0	13.2	19.5	.....	9.2	8.3	10.8	.....
Sept. 12	11.2	9.8	13.8	.....	9.4	8.3	11.2	.....	12.0	10.6	16.2	.....	9.0	8.3	10.5	.....
Sept. 26	11.0	9.8	12.6	.....	9.2	8.8	11.2	.....	10.5	9.3	14.0	.....	9.0	8.2	10.6	.....
Oct. 12	20.6	15.0	14.8	.....	9.0	8.2	10.8	.....	20.2	14.6	19.0	.....	8.7	7.9	10.3	.....
Oct. 25	15.8	12.8	14.2	.....	8.5	8.3	10.5	.....	16.6	13.1	17.2	.....	8.7	7.9	10.6	.....
Nov. 8	14.2	12.0	13.9	.....	8.9	8.3	10.5	.....	15.2	12.4	16.5	.....	9.0	7.8	10.6	.....
Nov. 29	13.4	11.2	13.8	.....	8.8	8.0	10.7	.....	13.4	11.6	13.2	.....	8.6	7.8	10.1	.....
1930																
April 8	17.6	16.0	17.2	16.2	17.6	14.6	11.3	14.8	17.7	14.7	18.0	17.0	18.0	14.8	11.4	14.9
April 22	16.6	15.6	17.7	16.3	16.6	14.4	12.1	15.2	16.6	13.8	17.0	17.0	17.0	14.4	11.6	15.4
May 6	15.2	14.0	16.8	16.0	15.0	14.0	12.0	14.7	15.0	13.2	17.3	17.0	15.5	13.2	12.0	14.0
May 20	13.2	12.6	16.6	16.0	13.6	12.4	11.6	14.8	13.4	12.0	16.0	17.0	13.9	12.4	11.3	14.6
May 27	19.6	15.4	21.1	21.6	21.2	15.8	19.0	16.9	.....	.....	.....	.....	.....	.....	.....	.....
June 3	17.9	16.2	20.7	19.0	18.1	15.6	21.2	19.4	11.4	10.8	16.0	16.6	12.0	10.7	11.6	14.5
June 18	13.6	13.0	18.2	17.8	13.2	12.8	18.6	18.1	10.0	9.0	15.0	16.0	10.3	9.9	11.4	13.0
June 26	13.0	12.7	18.8	17.2	13.0	12.0	18.8	18.2	.....	.....	.....	.....	.....	.....	.....	.....
July 1	20.6	18.0	22.2	20.4	18.0	14.1	21.4	18.5	9.5	8.3	13.8	15.4	9.6	8.8	11.2	13.7
July 15	14.4	13.3	18.6	19.8	13.8	13.0	18.6	20.6	9.2	8.1	13.4	15.8	9.4	8.8	10.8	14.5
July 21	.....	.....	.....	.....	.....	.....	.....	.....	18.8	14.0	18.5	18.2	.....	.....	.....	.....
July 29	11.5	11.2	16.3	19.0	11.2	10.2	15.6	19.4	14.0	11.3	18.9	17.4	9.0	8.1	10.1	13.3
Aug. 4	19.8	15.7	18.8	20.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 20	14.8	12.8	16.6	18.8	9.7	9.2	13.2	16.2	11.1	9.6	16.0	16.6	8.5	8.2	10.4	13.0
Sept. 12	12.4	11.6	15.6	17.4	9.0	8.4	12.7	16.4	9.2	8.3	14.8	15.2	8.1	8.0	10.4	12.8
Sept. 20	11.6	9.6	14.0	16.7	.....	.....	.....	.....	9.5	8.1	14.0	14.6	.....	.....	.....	.....
Sept. 30	19.0	12.7	14.4	18.2	9.4	8.9	12.6	16.6	17.6	9.8	13.6	16.6	8.5	8.0	10.8	13.0
Nov. 4	14.0	13.1	14.9	17.4	9.4	8.7	11.8	16.6	13.8	12.1	18.0	15.8	8.7	8.0	9.7	11.7

TABLE 6—*(Concluded)*

Date	Treatment A				Treatment B				Treatment C				Treatment D			
	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.	0-3 ft.	3-6 ft.	6-9 ft.	9-12 ft.
1931																
April 14	17.0	14.4	14.2	16.4	16.3	11.2	12.6	14.0	17.6	14.3	18.1	15.6	16.4	12.2	14.7	12.6
May 28	12.1	11.2	13.6	16.3	12.0	9.7	12.5	13.8	12.4	11.0	14.2	15.6	13.0	10.0	11.5	12.3
June 10	19.6	15.9	19.2	17.4	20.0	15.0	20.0	15.6	11.4	9.6	14.0	15.0	11.7	8.9	11.3	12.4
June 23	16.4	14.8	19.0	17.8	16.5	12.8	17.6	17.8	10.4	9.0	13.8	15.2	10.8	8.5	11.5	12.6
June 30	20.2	15.4	17.1	17.0	19.9	13.0	12.4	14.7	.....	.....	.....	.....	10.0	8.4	11.0	12.3
July 13	.....	.....	.....	.....	.....	.....	.....	.....	9.6	8.9	12.2	13.8	.....	.....	.....	.....
July 24	12.6	12.8	18.8	18.0	.....	.....	.....	.....	17.8	12.6	15.8	14.8	.....	.....	.....	.....
Aug. 4	19.8	18.2	19.6	17.8	12.9	10.2	14.5	16.8	15.4	12.2	16.7	15.6	.....	.....	.....	.....
Aug. 17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.2	8.0	10.7	12.0
Sept. 2	12.6	13.6	16.5	18.8	.....	.....	.....	.....	11.8	10.1	14.6	16.0	.....	.....	.....	.....
Sept. 11	19.9	16.6	21.1	20.2	10.7	9.6	11.7	17.1	18.9	14.3	18.6	18.4	8.9	7.8	9.8	12.4
Oct. 24	13.5	13.5	17.7	20.3	9.4	8.9	10.9	13.2	13.2	12.3	14.4	14.7	8.4	7.6	9.9	12.3
Nov. 19	15.5	13.9	16.9	21.0	12.1	9.4	10.7	13.0	15.0	12.2	16.3	15.9	10.9	8.0	10.0	12.0
1932																
Mar. 9	17.2	16.0	19.6	24.0	18.0	16.6	16.6	14.4	17.8	16.8	22.6	19.2	17.4	16.1	12.6	13.0
Mar. 31	18.7	16.8	22.3	26.1	19.5	16.9	19.2	16.2	19.4	16.8	23.9	23.8	19.0	16.3	15.2	13.7
May 16	14.2	14.3	21.2	24.6	13.7	14.0	17.6	16.6	14.3	13.8	21.5	22.9	15.0	14.1	15.1	13.4
June 16	11.8	11.5	17.6	23.9	11.6	10.8	15.2	15.4	10.8	9.2	17.2	19.6	11.8	10.9	13.1	13.2
June 24	18.9	15.3	19.8	23.0	18.7	11.9	14.7	14.8	.....	.....	.....	.....	.....	.....	.....	.....
July 7	15.1	13.4	17.8	21.8	14.4	12.0	15.8	16.8	10.3	9.2	15.4	18.3	10.6	9.6	13.1	14.0
July 20	18.5	13.2	18.2	24.2	12.8	11.4	15.0	17.7	20.6	15.9	18.1	19.6	10.4	9.2	11.7	12.8
Aug. 9	12.7	11.3	16.6	23.2	10.4	8.8	11.6	14.2	15.2	14.3	20.3	20.1	9.3	8.5	11.4	13.6
Aug. 17	20.6	16.3	17.8	23.5	.....	.....	.....	.....	21.1	16.4	23.2	22.4	.....	.....	.....	.....
Sept. 7	14.8	14.0	17.2	22.6	9.4	8.8	10.7	15.2	14.0	14.0	18.5	22.5	8.6	8.2	9.5	11.9
Sept. 23	13.4	11.9	15.5	22.4	8.8	8.0	10.2	13.2	13.2	11.8	18.1	19.4	8.1	8.1	10.6	13.2
Oct. 5	19.4	16.2	17.3	21.8	.....	.....	.....	.....	19.9	14.0	18.6	20.8	.....	.....	.....	.....
Nov. 14	14.7	14.6	17.0	22.2	9.2	8.3	10.2	12.1	14.6	13.1	16.9	19.8	8.5	8.0	10.0	12.1

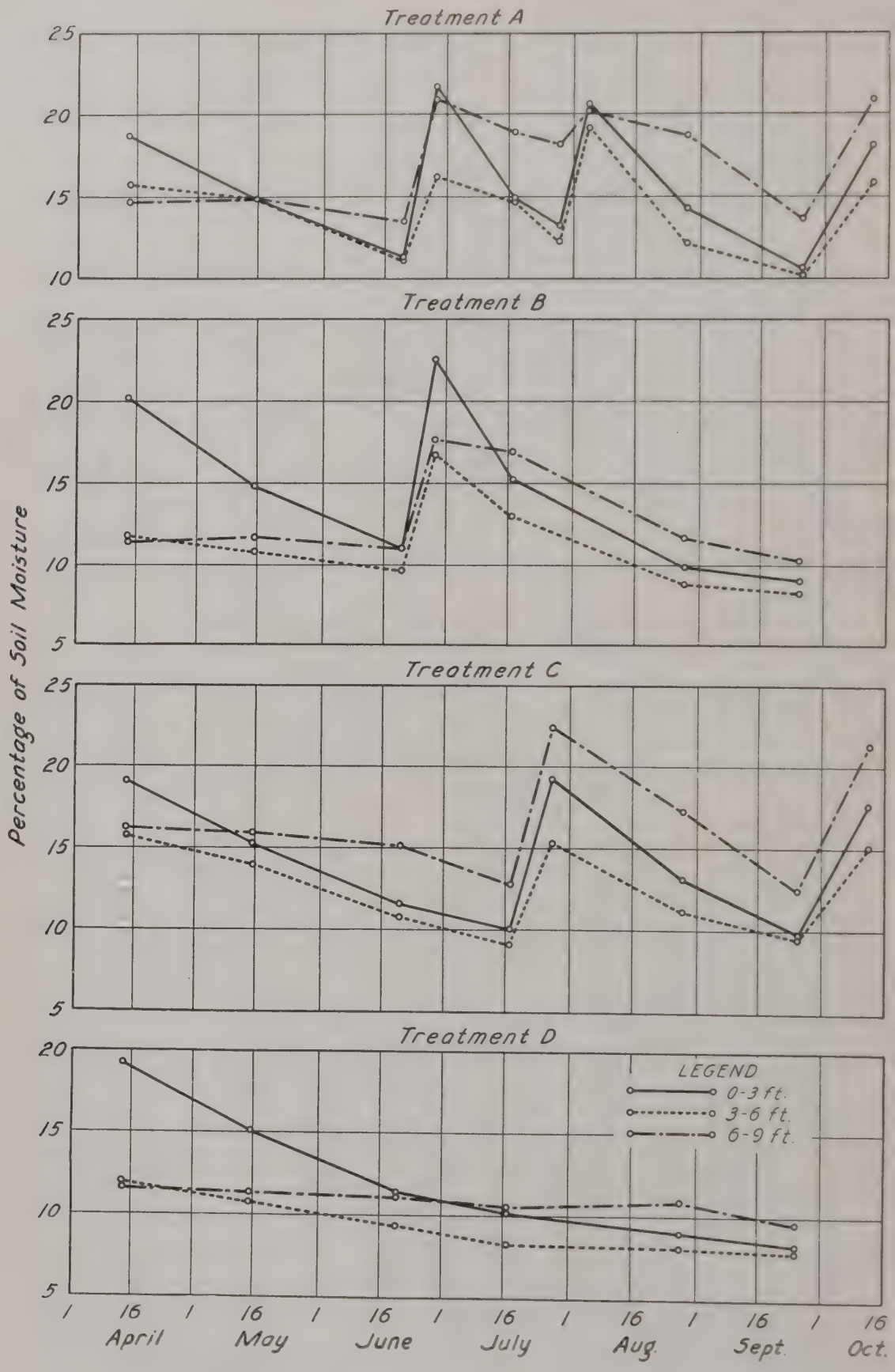


Fig. 5.—Soil-moisture conditions in the prune orchard in 1928.

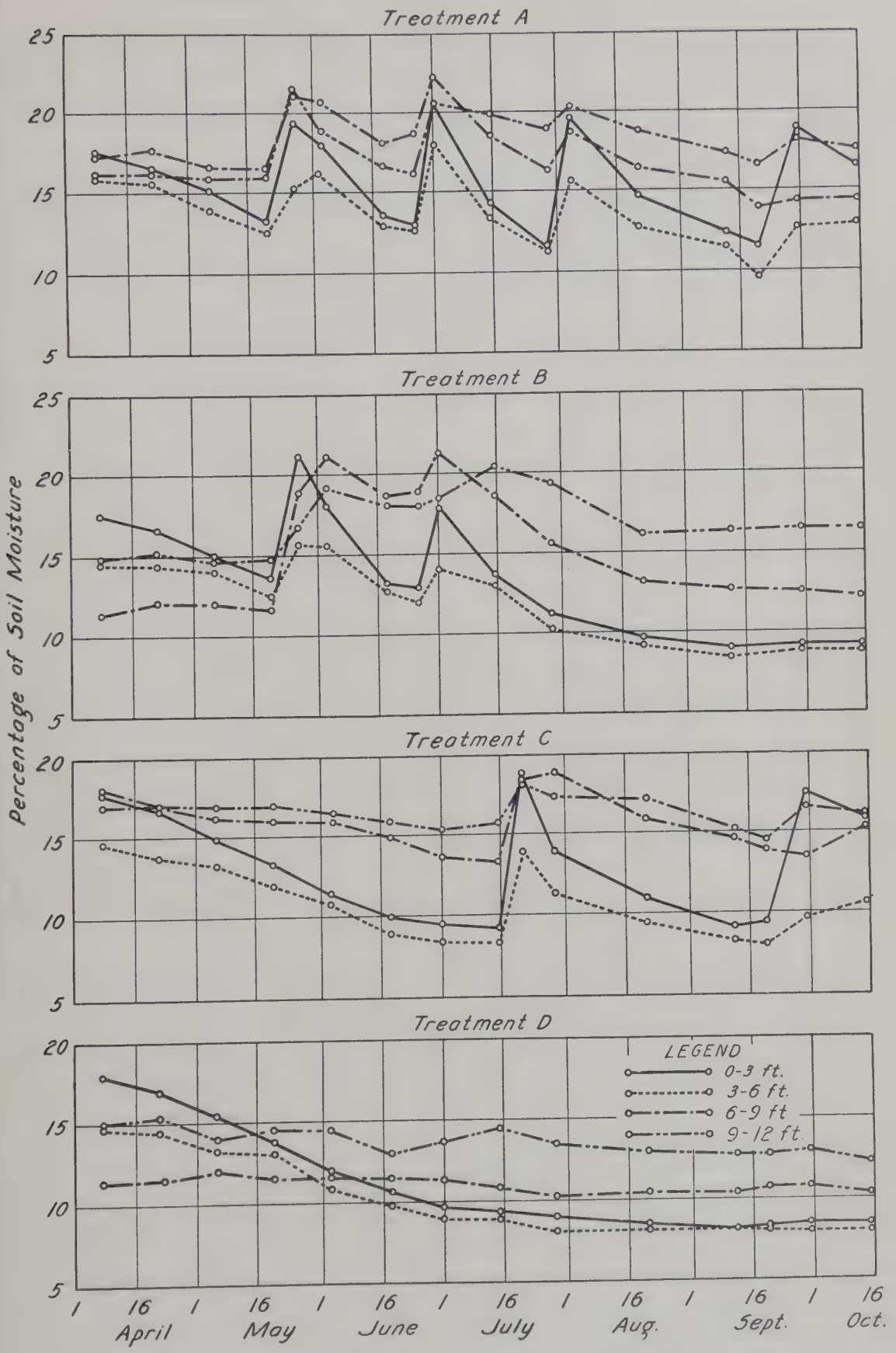


Fig. 6.—Soil-moisture conditions in the prune orchard in 1930.

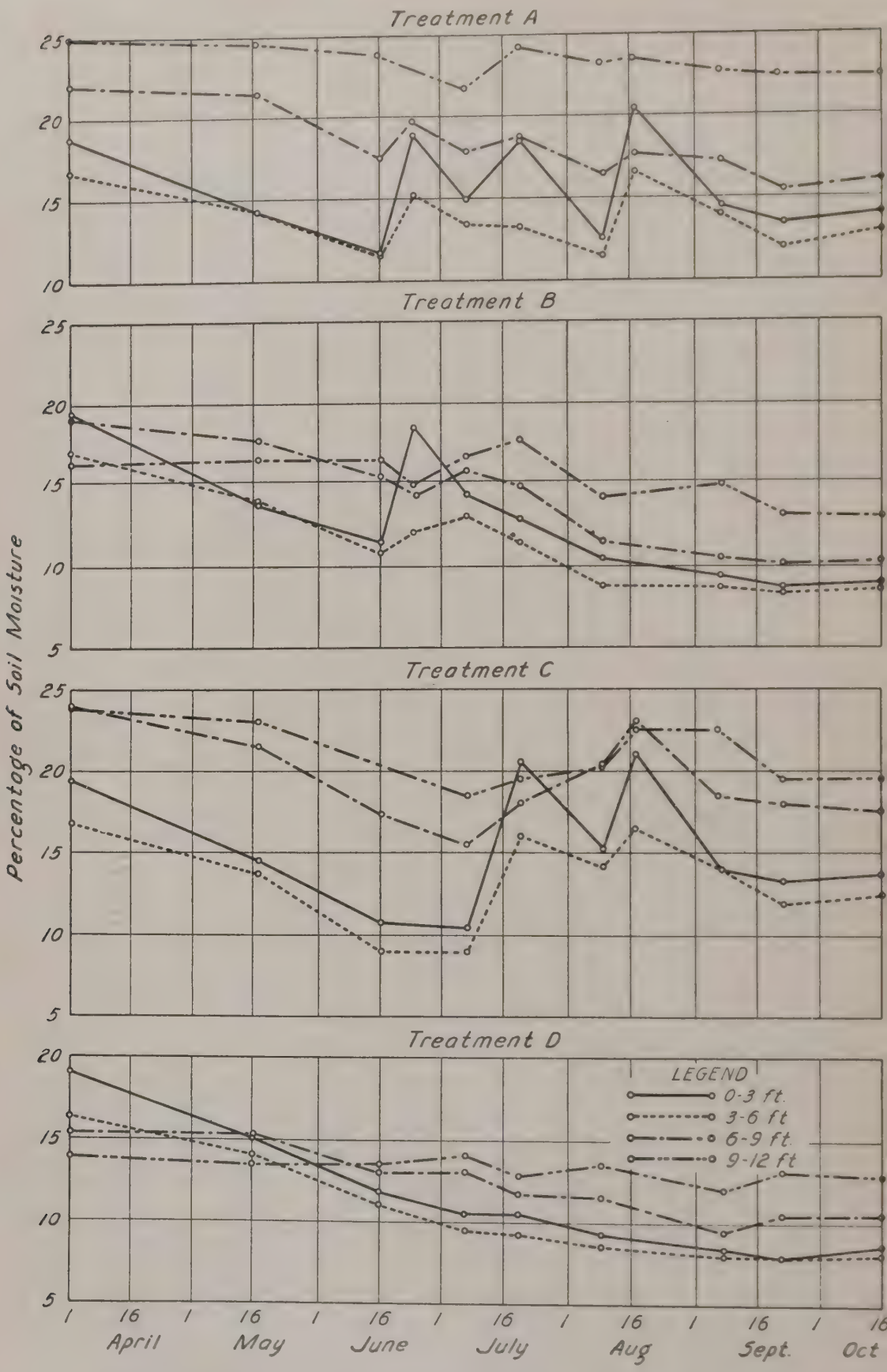


Fig. 7.—Soil-moisture conditions in the prune orchard in 1932.

In treatment C the soil was not reduced to the permanent wilting percentage in midsummer until 1928, as shown by tables 5 and 6. The average soil moisture, however, was reduced almost to the permanent wilting percentage July 23, 1926; but the area was irrigated the following day.

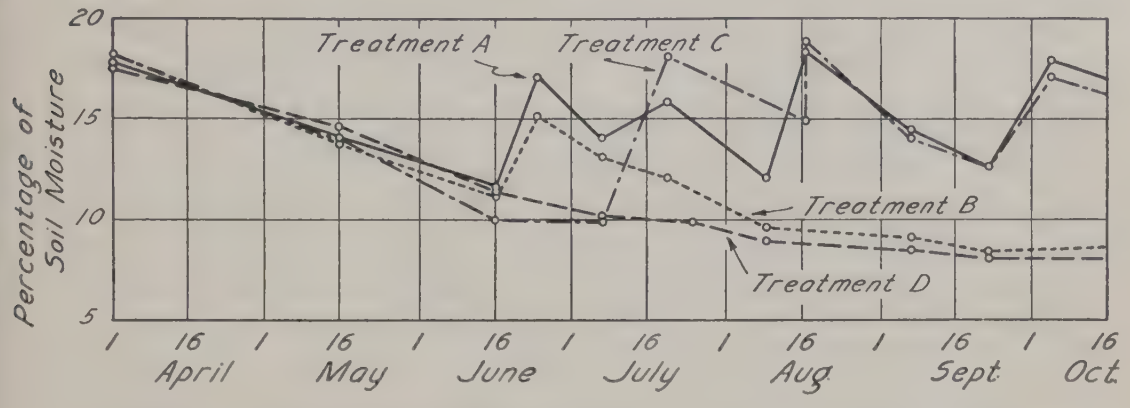


Fig. 8.—Average soil-moisture conditions in the top 6 feet in 1932.

The permanent wilting percentage in the top 6 feet of soil was reached on these approximate dates: July 15, 1928; July 22, 1929; June 18, 1930; June 23, 1931; and June 16, 1932. The trees were sometimes wilted for a few days late in the season because the irrigation was delayed to permit completion of the harvest. The permanent wilting percentage was reached about one month earlier in 1932 than in 1928, probably because of the increased tree size. The approximate period when the soil-moisture content remained at the wilting percentage, during the last 5 years of the experiment, is indicated by the irrigation and soil-moisture records in tables 3 and 6. The periods when the trees lacked readily available water up to 1930 were short; but in 1930, 1931, and 1932 they lasted about three weeks. As shown by the records for the last half of the experiment, some soil moisture was extracted from the 6 to 9 and the 9 to 12-foot depths, but was never exhausted. Since readily available moisture was found below 6 feet during the last half, it was probably present there during the early years also. Its presence at these lower depths did not prevent wilting.

In treatment D, in 1923, the average soil moisture was reduced to the permanent wilting percentage by September 5, in the upper 3 feet, but not in the 3 to 6-foot depth. In 1924, the 0 to 3-foot depth reached the permanent wilting percentage about September 2, while the 3 to 6-foot depth was close to it all season. From September 5, 1923, furthermore, until after November 21, 1924, the moisture content of the 3 to 6-foot depth was practically unchanged. In 1925, apparently little, if any, moisture was extracted after about July 15, because the trees were almost defoliated by red spiders. In 1926, the permanent wilting percent-

age was reached in the upper 3 feet about July 15, and almost reach in the second 3 feet. After the middle of the season practically no mo ture was extracted, because of another red-spider infestation. The pe manent wilting percentage, in the top six feet, was reached between Ju 20 and August 19, 1927; July 17, 1928; July 22, 1929; July 1, 1930; Ju 23, 1931; and July 20, 1932. The 6 to 9-foot depth contained readi available water throughout 1927. In 1928 its moisture content was clo to the permanent wilting percentage but did not reach it until late the season. In early spring of 1929, because of deficient rainfall, t plots in treatment D were irrigated. The 6 to 9-foot depth received so moisture, which was exhausted by about August 23, 1929. It reached t permanent wilting percentage about July 15, 1930. In 1931, at the b ginning of the season, it contained some available soil moisture, whic however, was exhausted about June 30. In 1932 the readily availab water at this depth was exhausted by about August 15. In this trea ment, D, the soil-moisture conditions in the 6 to 9-foot depth were pro ably no more severe during the early years of the experiment than du ing the last half. Apparently some readily available moisture was pre ent in the 9 to 12-foot depth during the years 1930, 1931, and 1932, a also during the earlier years.

TABLE 7

AVERAGE CROSS-SECTION AREAS OF THE TREE TRUNKS ARRANGED BY TREATMENTS

Year	Treatment A	Treatment B	Treatment C	Treatment
	sq. cm.	*sq. cm.*	*sq. cm.*	*sq. cm.*
1919	27.7± 1.4	25.9± 1.4	23.9± 0.7	28.6±0.5
1920	49.1± 2.0	47.8± 2.3	43.4± 1.1	50.3±0.9
1921	75.6± 1.7	73.1± 2.3	67.2± 1.3	76.1±1.3
1922	115.9± 3.1	110.7± 3.9	106.5± 2.4	117.1±2.1
1923	140.6± 3.0	138.1± 4.1	131.4± 3.0	141.9±2.2
1924	178.6± 2.7	162.1± 4.6	164.8± 3.7	166.5±2.1
1925	188.7± 4.2	173.4± 5.0	170.0± 4.7	177.2±2.9
1926	249.3± 6.0	232.2± 7.1	235.7± 6.9	223.8±3.6
1927	275.7± 8.2	255.4± 7.8	256.1± 8.0	242.7±3.8
1928	304.2±11.7	277.0±11.4	284.9±15.0	258.3±4.1
1929	360.4±10.4	326.2± 9.6	328.6±10.9	294.3±5.0
1930	368.2±10.5	335.6±10.1	335.7±11.3	300.0±5.3
1931	402.9±10.7	364.3±12.1	358.1±11.6	315.8±5.3
1932	423.6±12.7	378.7±13.0	372.1±12.1	327.8±5.3

Growth of the Prune Trees.—The average cross-section areas of t tree trunks when the plots are combined by treatments are given in tab 7 and figure 9. The curves show that during the first few years, when a trees had uniform treatment, the average increase in growth was esse tially equal for all. Thus, from 1919 to 1922, inclusive, all trees grew approximately the same rate; and those that, on the average, were sma to start with, were the smallest at the end of this period. In 1923, wh

differential irrigation treatment was started, no significant differences in size of trees were obtained. The trees in treatment A became the largest, however, in 1924, and have maintained this relative position since that time. By the end of 1924 the average cross section of their trunks was significantly larger than that in D. As previously mentioned, soil-

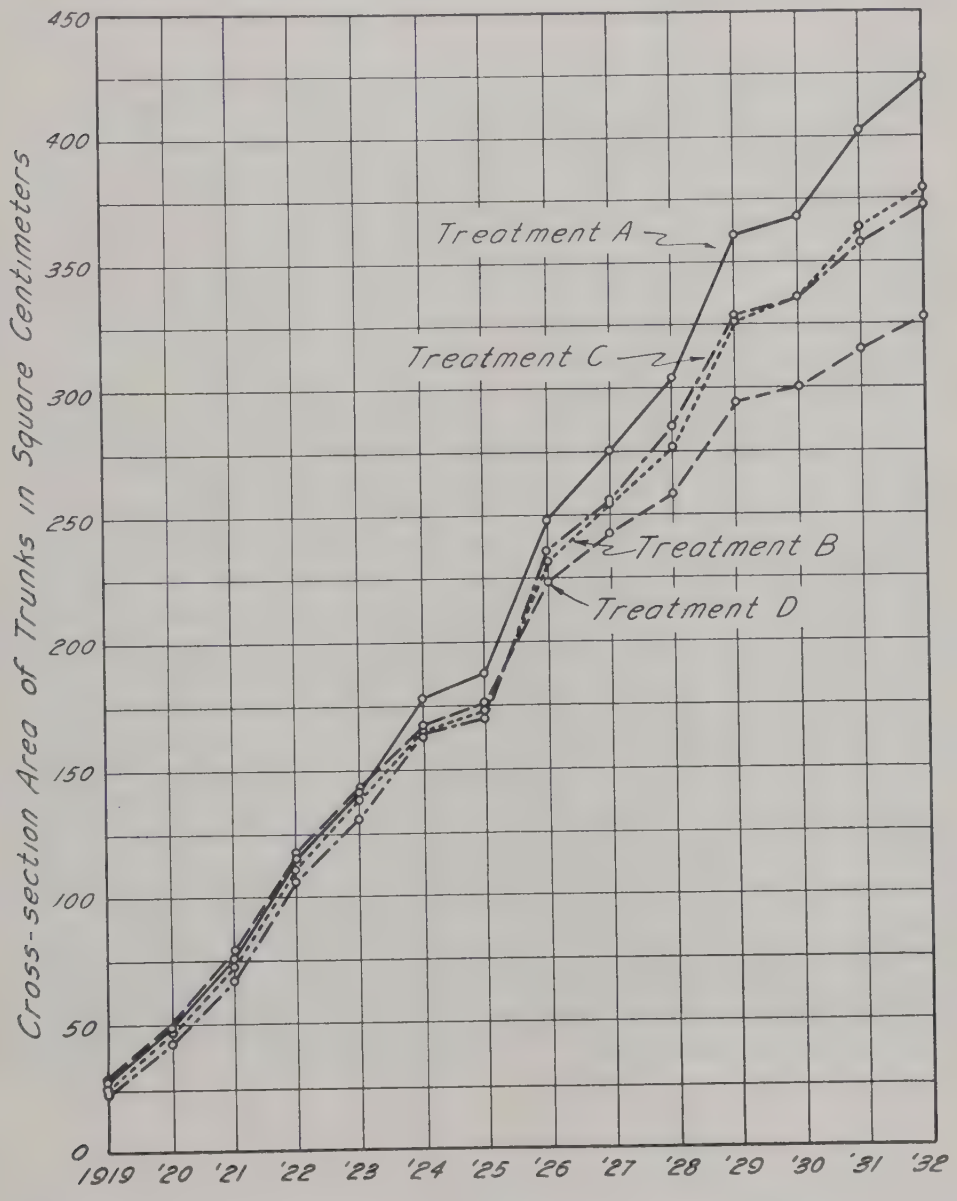


Fig. 9.—Average growth of the prune trees from 1919 to 1932, inclusive.

moisture conditions in D were severe: practically no available water was present in the 3 to 6-foot depth during the season, nor in the top 3 feet after September 2, 1924. The trees in A remained significantly larger than those in D except in 1925, when the soil moisture in the latter did not reach the permanent wilting percentage until late in the growing season.

The trees in A were always slightly larger than those in B, the difference increasing as the experiment progressed. The differences are not, however, statistically significant, though the odds calculated by the Bessel method were 10 to 1 in 1932. Odds of 30 to 1 or, where the results may be attributed to the experiment and not to chance, 29 times out of 30 are usually assumed to be significant. In this case, however, the fact that the trees in A became larger than those in B, and remained so, is



Fig. 10.—A typical prune tree in treatment A; February 1, 1933.

strong evidence that the cause was the irrigation treatment and not chance. In general, the differences between tree sizes in A and C were essentially the same as those between A and B. In B and C they are too small to be considered significant.

The trees in D were slightly larger than those in B and in C up to the end of the 1925 season. Since then the trees in B and C have been progressively larger than those in D. The differences between B and D, and between C and D, were significant in 1931 and 1932.

The rate of growth of trees in all plots was influenced by factors other than irrigation. These other factors, however, seemed to affect all growth

in about the same way. In 1925, for example, a heavy infestation of red spiders appreciably decreased the growth rate of all the trees. In 1929 the rate was increased because a spring frost destroyed most of the crop. In 1930, when the crop was very heavy, the rate was appreciably decreased.

In general, the unirrigated trees resembled prune trees grown in districts with comparable rainfall and soil conditions where irrigation is



Fig. 11.—A typical prune tree in treatment D; February 1, 1933.

not practiced. They seemed to have fewer small branches (figs. 10 and 11) and fewer leaves than the irrigated trees. In summer they looked like healthy trees with a rather scant foliage. The trees in treatments B and C appeared, in general, similar to those of A. The growth of new shoots in D was noticeably less than in A. In all treatments, the trees blossomed and started growth at approximately the same time each year. No winter killing of twigs was observed, even when a minimum temperature of 10° F was reached.

Yields of the Prune Trees.—In 1923 the trees bore the first crop that warranted harvesting. In the next three years the yields were light and

irregular. There also seemed to be a tendency toward alternate bearing, the yields being lighter in 1924 and 1926 than in 1923 and 1925. The first moderate crop, produced in 1927, was followed by a light crop in 1928. In 1929, when a spring frost injured the blossoms, the yield was exceptionally light, except in one corner of the orchard. The crop in 1930 was extremely large, averaging from 16 tons of fresh fruit to the acre in treatment A, to 8 tons in D. The next year, 1931, the yield was light; in 1932, moderate. The average yield per tree arranged by treatments will be found in table 8, and the cumulative yields in table 9.

TABLE 8

AVERAGE YIELDS OF FRESH PRUNES PER TREE ARRANGED BY TREATMENTS

Year	Treatment A	Treatment B	Treatment C	Treatment D
	pounds	*pounds*	*pounds*	*pounds*
1923	53.1± 3.9	58.7± 4.0	51.1± 3.9	62.6 ± 3.9
1924	15.6± 3.7	13.5± 1.9	8.6± 1.4	7.9 ± 0 7
1925	42.3± 6.6	8.2± 1.4	52.7± 6.8	57.6 ± 3.9
1926	41.0±10.6	13.4± 3.1	13.5± 2.7	4.6 ± 0.8
1927	284.2± 6.2	272.3±10.1	301.2±11.1	255.2*± 8.9
1928	120.3±18.8	86.6±11.5	91.9± 9.8	76.4*± 9.9
1929	22.3± 7.3	10.8± 2.0	11.9± 3.6	39.6*± 9.1
1930	505.0± 9.4	460.2±15.4	373.2±10.2	284.6*±14.1
1931	15.0± 3.4	26.3± 2.9	14.9± 1.3	15.1*± 1.1
1932	225.2±13.9	220.3±12.2	217.4± 9.7	157.2*± 7.1
Average 1927-1932	195.3±15.5	179.4±14.4	168.4±12.6	138.0 ± 7.5

* Average of 19 trees. Tree 11, row 14, was omitted because of crown gall.

TABLE 9

AVERAGE CUMULATIVE YIELDS OF PRUNES

Year	Treatment A	Treatment B	Treatment C	Treatment D*
	pounds	*pounds*	*pounds*	*pounds*
1927	284.2± 6.2	272.3±10.1	301.2±11.1	255.2± 8.9
1927-1928	404.5±19.8	358.9±15.3	393.1±14 8	333.9±13 3
1927-1929	426.8±21.1	369.7±15.4	405.0±15.2	373.5±16.1
1927-1930	931.8±23.1	829.9±21.8	778.2±18.3	660.8±21.4
1927-1931	946.8±23.3	856.2±22.0	793.1±18.4	675.7±21.4
1927-1932	1172.0±27.1	1076.5±25.1	1010.5±20.8	832.9±22.6

* Average of 19 trees. Tree 11, row 14, was omitted because of crown gall.

The yields for the first four years were small, probably because of tree size, and irregular, the yields from treatment D being larger than those from A in two years out of the first four, and the yields from B much smaller than those from the other three treatments in one year of the four. Because of these irregularities and, because the size of the trees prevented the expected soil-moisture conditions from being obtained in all treatments, the yields of the first four years are considered separately in judging the effect of soil moisture on yields.

The average annual yields of treatment A were larger than those of B from 1927 to 1932 inclusive, except in 1931. During these years the permanent wilting percentage in the top 6 feet in B was reached about the middle of August except in 1931, when it was reached in September. These differences in yields, however, are not statistically significant.

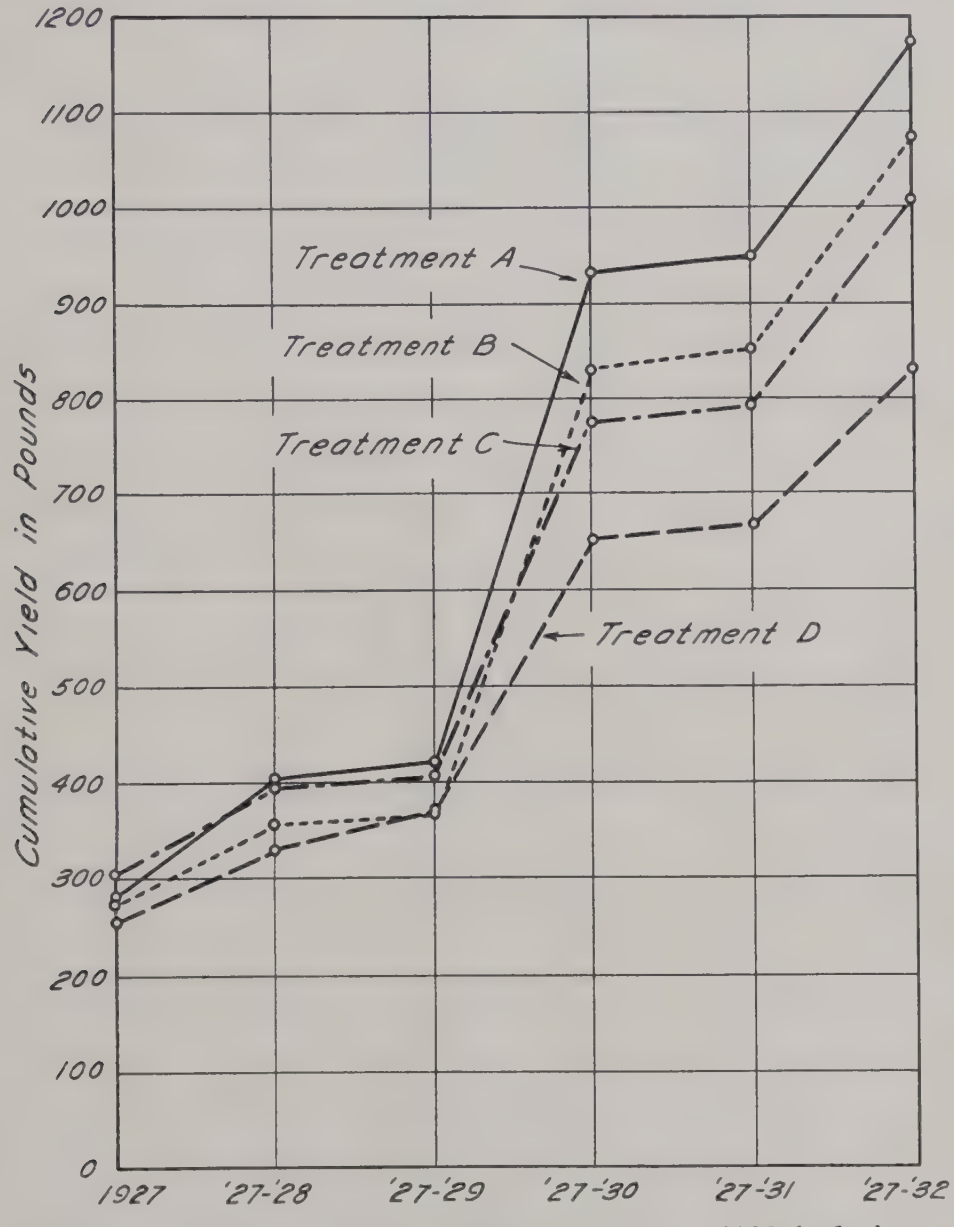


Fig. 12.—Average cumulative yields from 1927 to 1932, inclusive.

The yields of treatment A were larger than those of C, except in 1927; but the differences were statistically significant only in 1930, the first year in which the soil moisture in C reached the permanent wilting percentage in the top 6 feet and remained there for a considerable period.

The yields from treatment A were larger than those from D except in 1929, when the latter were affected less by the frost of that year than those of A; and in 1931, when the crop was very light because of the

large yield in 1930. The differences were statistically significant in 193 and in 1932. The soil moisture in D was reduced to the permanent wilt ing percentage by about July 15 except in 1927, when it was reached a week or two later.

The yields from treatment C were larger than those from B in 1927 1928, and 1929, but were smaller in the following three years. Statisti cally significant differences were obtained in 1930 and 1931. The yield from B were larger than those from D, except in 1929, the difference being statistically significant during the last three years. The yield from D were larger than those from C during 1929 and 1931; but smalle the other years, and significantly so in 1927, 1930, and 1932.

TABLE 10

AVERAGE DIAMETERS OF FRENCH PRUNES, 1932

Date	Treatment A	Treatment B	Treatment C	Treatment D
	cm.	*cm.*	*cm.*	*cm.*
April 29	1.24	1.25	1.24	1.25
May 5	1.37	1.37	1.36	1.41
May 13	1.56	1.53	1.51	1.59
May 20	1.73	1.70	1.70	1.78
May 26	1.80	1.77	1.77	1.86
June 3	1.92	1.88	1.88	1.97
June 10	2.04	2.00	1.99	2.09
June 17	2.15	2.08	2.09	2.20
June 24	2.33	2.25	2.21	2.34
July 1	2.53	2.46	2.35	2.48
July 8	2.70	2.62	2.47	2.59
July 15	.....	2.79	.....	2.68
July 22	2.95	2.87	2.66	2.70
July 29	3.04	2.92	2.72	2.73
August 5	3.06	2.94	2.75	2.75
August 12	.....	2.96	.....	2.78
August 19	3.06	2.94	2.79	2.78
August 26	2.95	2.81	2.69	2.64

The cumulative yields from 1927 to 1932, inclusive, obtained by add ing the successive average yields together, are shown in table 9 and i figure 12. Those from A were larger than those from B, but significantl larger only in one case. In 1927 the yield from C was larger than tha from A; but thereafter the cumulative yields from A were larger tha those from C, and significantly so during the last three years. The yield from A were significantly larger than those from D for four years out o the last six, and were nearly so in 1927. The frost in 1929 probably ex plains the lack of a decisive difference in the cumulative yields of thes two treatments that year.

The cumulative yields from treatments B and C show that the latte were larger from 1927 to 1929 inclusive, and smaller the other thre

years. The difference between these two treatments, though not significant, apparently increased slightly from 1930 to 1932, inclusive. Except in the frost year, 1929, the cumulative yields from B were larger than those from D—significantly so the last three years. Those from C were significantly larger than those from D, or nearly so, except in 1929.

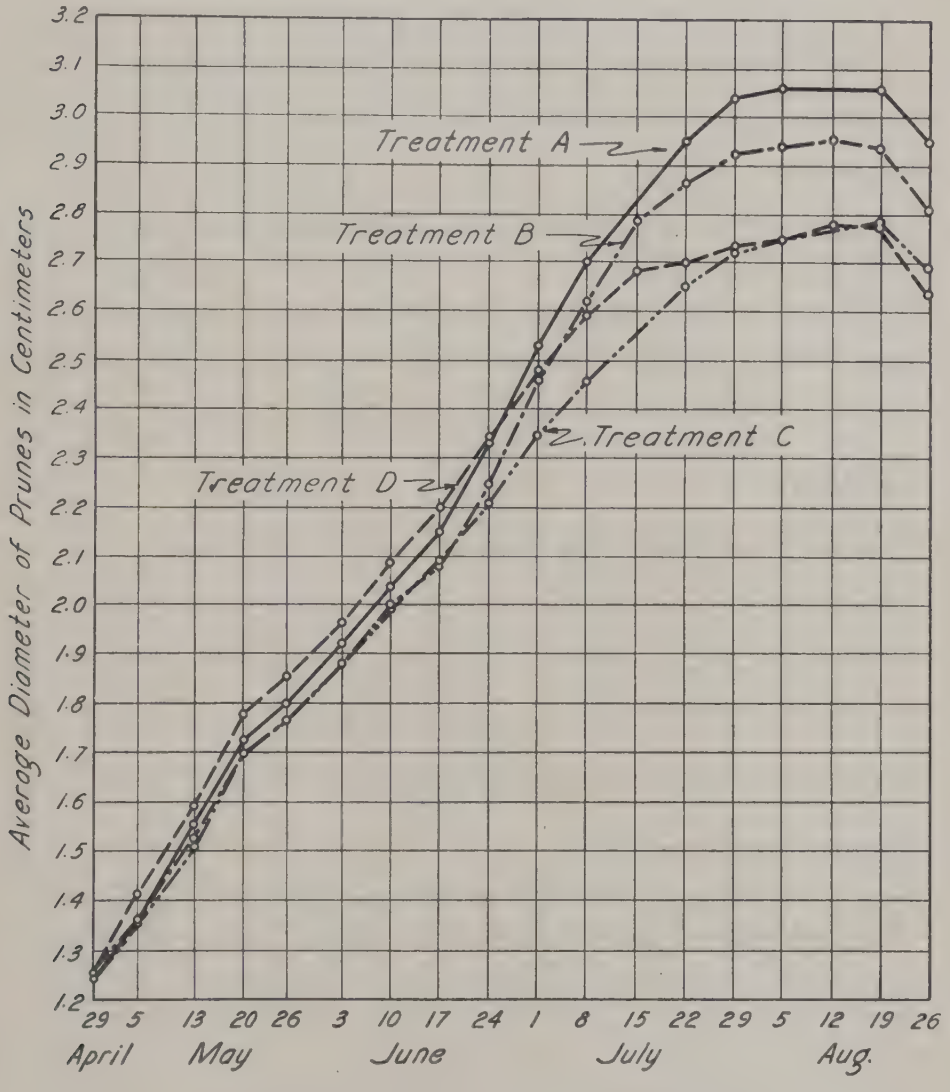


Fig. 13.—Growth of the prunes in 1932.

Rate of Growth of the Fruit.—In 1932, the tenth year of the experiment, the growth of fruit was measured at weekly intervals during the months of May, June, July, and August. Sixty fruits in each of treatments A, B, and C, and 120 in D were first marked with a small spot of india ink approximately 90 degrees from the suture and then measured with calipers.

The average sizes of these fruits are shown in table 10 and in figure 13. As the curves show, the fruit in all plots was about the same size on April 29. Thereafter, until June 24, the fruit was slightly larger in D

than in the other treatments. In general, the fruit reached full size from two to four weeks before harvest. The dates on which the fruit proved significantly smaller in some treatments than in others correspond closely to the dates when the available soil moisture in the former treatments was exhausted.

Significant differences in average fruit sizes were obtained between treatments A and B on and after July 29; between A and C, on and after June 24; between A and D, on and after July 8. The probable errors for the size measurements in A, B, and C, in almost every case were ± 0.02; those for D, ± 0.01. Differences of 0.09 centimeter or more between A and B, A and C, or B and C are significant by odds of 30 or more to 1. Differences of 0.07 centimeter or more between D and any one of the other treatments are also significant. The fruit in B was significantly larger than that in C on and after July 1. It was larger than that in D on and after July 15, although the latter had been significantly larger from May 20 to June 24. Likewise, the fruit was significantly larger in D than in C from May 13 to July 8, after which they were nearly the same size for several weeks.

As shown by the record for 1932 (fig. 8), the available soil moisture in the upper six feet in treatment C reached the permanent wilting percentage about June 16. Approximately a week later, the fruit in C was significantly smaller than that in A; about two weeks later, significantly smaller than that in B. The latter was significantly smaller than that in A on July 29. On the next sampling date, August 9, the soil of treatment B was reduced to the permanent wilting percentage. Probably, because this condition occurred in D two or three weeks later than in C, the fruit in D did not become significantly smaller than that in A and B until about two weeks later than did the fruit in C. As the curves show, the rate of growth in C was appreciably decreased during the latter part of June, when this treatment lacked readily available water; and, even when irrigated again, the fruit did not reach the size of that in treatments A and B. The measurements a few days before harvesting showed a marked decrease in size, probably because of a partial drying on the trees.

Sizes of the Dried Fruit.—During the last three years of the experiment, the dried fruit was run through a mechanical sizer having six screens, with openings of 28/32, 30/32, 32/32, 34/32, 36/32, and 38/32 inches. Table 11 gives the results as percentage of the total dried crop from each treatment. Table 8, in which the annual yields are compared with the distribution of sizes, shows how the total fruit produced influences the average size of the individual fruits. Thus in 1930, when the crop was heavy, nearly all the fruit was small; while in 1931, with a

light crop, the individual fruits were usually large. In 1932, with an average crop, the percentage of large prunes exceeded that of 1930, but was smaller than in 1931.

TABLE 11

SIZES OF DRIED PRUNES EXPRESSED AS PERCENTAGE OF THE DRY YIELD AND AS THE AVERAGE NUMBER OF PRUNES TO THE POUND

Treatment	Screen sizes in inches						Over end of sizer	Average number prunes per pound
	28/32	30/32	32/32	34/32	36/32	38/32		
				1930				
A	62.7	26.4	7.8	2.7	0.5	0	0	131.2
B	59.4	23.3	11.8	4.6	0.9	0	0	106.3
C	65.2	24.9	7.6	2.2	0.1	0	0	139.8
D	76.2	18.2	4.4	1.2	0.0	0	0	143.6
				1931				
A	0.4	0.9	2.2	5.4	10.3	17.4	63.4	44.3
B	0.5	2.2	5.8	10.0	15.6	22.2	43.7	47.6
C	1.1	1.7	3.7	9.5	17.7	22.1	44.2	43.4
D	1.7	4.6	9.8	15.5	21.0	20.9	26.5	48.8
				1932				
A	27.5	22.5	18.7	14.3	9.4	4.4	3.2	86.6
B	25.3	25.1	21.7	15.0	8.2	3.3	1.4	88.7
C	33.1	24.8	19.8	13.1	6.1	2.1	1.1	92.5
D	41.3	30.0	16.8	7.7	3.0	0.9	0.3	97.4

The smallest fruits were produced in D, the unirrigated treatment. The differences in dried-fruit size in A and B are small except in 1930, when B produced larger prunes. The average size produced by C in 1930 and in 1932 was slightly smaller than that from both A and B. In 1931 this situation was reversed, the fruit from C being slightly larger than that from A and B, although the soil-moisture conditions in C were similar during all three years. On the average the fruit of the experimental orchard is smaller than that from most other prune-growing sections.

Ratios of Fresh to Dry Weight of Fruit.—The drying ratios, or ratios of fresh to dry weight of fruit, for the last six years of the experiment are given in table 12. The results in 1927, 1928, and 1929 were obtained by sun-drying; those in 1930, 1931, and 1932, by dehydration. Those for 1928 and the last three years were corrected to a uniform moisture content of 20 per cent. As the fruit from each tree could not well be dried separately, that from each plot was dried as a unit. As the data show, the drying ratios from any one treatment are not consistently higher or

lower than those from any other. In some cases the differences from one year to another are greater than those between treatments. The latter are so slight as to have little or no significance; however, the average drying ratio for six years for treatment A was 2.7 to 1; for B, 2.7 to 1; for C, 2.7 to 1; and for D, 2.6 to 1. The variations in drying ratios from one year to another may result from the method of harvesting. The fruit is allowed to fall or is shaken to the ground as in commercial practice.

TABLE 12

RATIO OF FRESH TO DRY WEIGHT OF PRUNES

Year	Treatment A	Treatment B	Treatment C	Treatment D
1927*	3.1	3.1	3.1	3.2
1928	2.5	2.5	2.3	2.3
1929*	2.0	2.3	2.0	2.0
1930	3.3	3.0	2.9	3.0
1931	2.5	.....	2.7	2.3
1932	2.9	2.8	3.0	2.6

* Not calculated to a uniform moisture content. The other drying ratios are calculated to 20 per cent moisture.

It may lie on the ground for a longer period in certain years than in others. The fruit from any one treatment, however, did not ripen and drop earlier than that from any other. The partial drying before the crop can be picked up and weighed undoubtedly influences the drying ratio. The slight differences in drying ratios in A, B, C, and D are not explained by the irrigation treatment.

TABLE 13

SUGAR AND ACID CONTENTS OF FRESH PRUNES AND SPECIFIC GRAVITIES OF DRIED PRUNES ARRANGED BY TREATMENTS

Year	Per cent total sugar on fresh-weight basis				Per cent acid as malic on fresh-weight basis				Specific gravity			
	A	B	C	D	A	B	C	D	A	B	C	D
1930	11.86	11.67	12.00	11.63	.....	.....	.....	.....	1.25	1.25	1.21	1.20
1931	13.80	13.84	14.26	13.71	0.81	0.85	0.89	0.88	1.19	1.17	1.18	1.19
1932	11.78	12.06	11.50	11.60	0.67	0.69	0.66	0.69	1.07	1.10	1.09	1.10

Sugar and Acid Contents and Specific Gravities.—The total sugar and acid contents, expressed as percentages of the fresh weight of fruit, and the specific gravities are given in table 13. The sugar and acid contents were obtained from composite samples of 125 fruits from each plot; the sugar analyses, from material preserved in alcohol by the Schaefer-Hartmann method. Although the differences in sugar contents were small, the percentage of sugar in D was slightly lower than that in

A in every case, and slightly lower than that in either B or C in every case except one. No consistent differences in sugar contents of fresh fruit appeared between A and either B or C. All treatments contained more sugar in 1931 than in either 1930 or 1932. During the two years when acidity tests were made, the acid contents of the fruit were substantially the same for all treatments each year.

After curing, the dried prunes were separated into seven sizes. Samples of each size from all plots were used in specific gravity determinations, made by the method of Nichols and Reed,[3] who have shown that such determinations may be used as a measure of quality. The specific gravities given in table 13 are the averages of those of the seven sizes; they differ so slightly in any one year that they appear unaffected by the irrigation treatment. On the average, however, they were slightly higher in 1930 than in the other two years. Observation of the quality by cutting 300–400 prunes from each plot showed that the flesh was lighter colored and the gas pockets were fewer in 1930 than in either 1931 or 1932. The yield record shows a heavy crop for 1930, a light crop for 1931, and a moderate crop for 1932. The specific gravity, too, was higher and the observed flesh color better when the crop was heavy (1930) than when it was very light (1931) or moderate (1932). As these data show, the specific gravity of the dried product was not influenced by the irrigation treatment.

DISCUSSION

Soil Moisture and Growth of the Trees.—The differences in growth of the trees shown in figure 9 agree with soil-moisture conditions. The trees in treatment A were larger than those in D in 1924 and 1925, and have clearly diverged from them since the end of the 1926 season, as shown in figure 9. The differences between A and B and between A and C have, in general, been increasing, but are not statistically significant, although those between A and C are nearly so in 1931 and 1932. In size, the trees of treatments B and C do not differ significantly, whereas those of D have clearly been diverging from both of them. Evidently growth was retarded by allowing the trees to reduce the soil moisture to about the permanent wilting percentage during certain parts of the growing season and to remain wilted for a considerable length of time.

By the end of 1932, although B was smaller than A, the difference was not significant. This fact is surprising, when one considers the relatively long period each year since 1927 that B was without readily available water in the top six feet. A possible explanation may be that both these treatments had readily available moisture (fig. 8) in the spring and early summer, when the circumference increases rapidly. After the

spring growth, the slower increase during the laying down of the summer wood in the annual rings was evidently not greatly influenced by the different soil-moisture conditions in the two treatments. Inasmuch as D reached the permanent wilting percentage two or three weeks before B, this dry period may have come early enough to influence the circumference increase during the rapid spring growth. With the trees in C, furthermore, since the dry period occurred earlier than in B, even though it was relatively short, it may have checked the rapid spring growth; and the late summer irrigations did not increase the growth sufficiently to compensate. Readily available water below six feet is relatively unimportant, as discussed later.

The importance of maintaining readily available moisture in June and early July is shown by comparing the growth of trees in A, B, and C. The relatively short period in midsummer, when C lacked readily available moisture, checked this growth as effectively as did a much longer period later in the season in B. Both the soil-moisture records and the tree measurements indicate that the permanent wilting percentage is a critical soil-moisture condition, and show that lack of readily available water affects growth more in midsummer than in late summer.

Though periods of drought at various times during the season influenced the comparative differences in tree size, other factors were important. For example, the rate of growth was decreased in all plots, first in 1925, by a severe red-spider infestation, and again in 1930, by a heavy crop. On the other hand, the trees grew a little faster than usual in 1929, when a late frost killed nearly all blossoms.

Considering the severity of the treatment, the trees in the unirrigated plots were remarkably thrifty after the first eight or nine years of the experiment. Some of the upper branches, however, died back two to three feet in 1932. According to these results, prune trees on a fertile soil can withstand a lack of readily available moisture for a relatively long period each season and still produce fair crops for a number of years.

On the other hand, readily available moisture maintained in the fall did not cause growth that was susceptible to injury by the temperatures ordinarily prevailing in the prune-growing sections of California. Whether irrigated in the fall or allowed to enter the dormant period in a wilted condition, the trees showed no evidence of injury by low temperatures during the winter months.

Soil Moisture and Yields.—As previously mentioned, the trees began to bear the year the differential irrigation treatments were started. For the first four years the yields were small and irregular, possibly because of the age of the trees. In addition, because of tree size, the desired soil-

moisture conditions were not obtained in all treatments. The yields for the first four years, therefore, are considered separately in the following discussion.

Apparently, the reason that the yields did not follow the same general trend during the first four years as during the last six was that the soil moisture in some treatments was not reduced to the permanent wilting percentage early enough in the season to affect the yields. The general results with growth and yields of prune trees agree with other experiments[1, 2, 4] in which differences were not obtained until the soil moisture neared the permanent wilting percentage.

The pronounced differences in soil-moisture conditions after 1926 would lead one to expect larger differences in yield than were actually obtained. The annual records illustrate the difficulties encountered in interpreting yield data from single years. Obviously, the frost in 1929 and the heavy crop of 1930 tended to mask any effects of the irrigation; but even with these years excluded, annual yields differed significantly in less than half the possible cases. These results are rather surprising because treatments B and D lacked readily available water for relatively long periods as early as 1927. The average annual yields, however, indicate that A produced the largest yields, followed by B, C, and D in order. Only the differences between A and D are statistically significant. Evidently, therefore, prune trees at Davis may lack readily available water for considerable periods, especially in late summer, without materially lessening the yields.

The grower, though interested in yields for any one year or in the average yield for a number of years, may also be concerned with the total yield over a number of years. Table 9 shows that on the average the trees in treatment A in the years from 1927 to 1932, inclusive, produced 1,172 pounds of dried fruit each; those in B, 1,076 pounds; those in C, 1,010 pounds; and those in D, 828 pounds.

According to these results, shown graphically in figure 11, the irrigation treatments have brought about increasing differences in cumulative yields. These differences, however, have not always increased regularly. In comparing severity of treatments under Davis conditions, for example, one notes that a period of two to three weeks without readily available moisture in the soil during one part of the season may affect the trees and yields as decisively as a longer period at another time. Treatment C, for example, was dry for a relatively short time each year during late June and early July. Despite favorable soil-moisture conditions later in the season, the cumulative yields from this treatment were slightly, although not significantly, smaller than those from B, which was dry from about the middle of August until the fall rains, several

months later. The trees in D were subjected to approximately the same soil-moisture conditions as those in C in late June and early July and, in addition, remained dry until the fall rains (usually in late October or November).

As shown by the records, not only the length of time the soil lacks readily available moisture, but also the season when the soil moisture nears the permanent wilting percentage, must be considered in interpreting growth and yield data. The records for treatments B and C illustrate this point, because C lacked readily available water for a comparatively short period in midsummer, B for a much longer period beginning about the middle of August. If length of time is considered without regard to season, the order of growth and yields should be A, C, B, and D; but this was not the case. If, however, the two treatments reached the permanent wilting percentage at the same time, the one that remained there the longer may be affected the more severely.

Effects of Fall Irrigation on Growth and Yields.—The fact that the soil in some treatments was dry for considerable periods in the fall without greatly affecting the growth or yields agrees with observed results in many unirrigated commercial prune orchards throughout California. The trees in these orchards, though smaller and less productive than those in other irrigated orchards in the same region, yield fairly satisfactory crops. Usually, the trees are growing on soils of relatively high water-holding capacity and are of such a size that the permanent wilting percentage is not reached until relatively late in the season. Fairly satisfactory crops, no doubt, are produced in many commercial orchards where the soil moisture remains close to the permanent wilting percentage for relatively long periods in the latter part of the season of each year.

The fact that neither the rate of growth of fruit nor the general appearance of the trees were affected until the readily available moisture was exhausted, indicates that the moisture requirements of prune trees are fulfilled if the soil moisture is maintained above the permanent wilting percentage. Even if, however, the trees are allowed to exhaust the readily available moisture after about the middle of August, as in treatment B, the yields may not be materially affected. After ten years of such treatment, the yields of B were only slightly smaller than those of A, even though the cross-section areas of the trunks are becoming progressively larger in A than in B. The difference in tree size in the two treatments may later become sufficient to affect the yields more than during the past ten years. Judging, however, from results thus far, the omission of a fall irrigation was not followed by such serious consequences as might have been expected.

Soil Moisture and Growth of the Fruit.—The lack of readily available soil moisture was reflected, however, in the growth of the fruit. In 1932, the fruit in treatments C and D grew more slowly when the soil moisture was close to the permanent wilting percentage. The fruit in B grew more slowly than that in A toward the end of the season, when the readily available water in B was exhausted.

Treatment C lacked readily available soil moisture for only about three weeks during the last part of June and the first part of July, but the effect was very marked. Although in the treatment irrigation was applied shortly after this dry period, the fruit remained smaller than that of A and B. These results are similar to those obtained with peaches.[1]

The fruits on the irrigated and nonirrigated treatments show interesting differences in the rates of growth. At the beginning of the season, after ten years of differential irrigation, they were all approximately equal in size and in rate of growth until the soil moisture in certain treatments was reduced to about the permanent wilting percentage. Evidently the rate of growth of prunes is affected by soil moisture only when the readily available water in the top 6 feet is exhausted, and can be detected only when fruits on treatments having no readily available soil moisture are measured and compared with those from treatments having such moisture. During the early part of the season, furthermore, when water was still readily available, growth of fruit was not affected by the soil-moisture conditions of the previous year. In other words, the previous summer's irrigation treatment had no "holdover" effect on the fruit.

In comparing growth and soil-moisture extraction curves, one sees a decrease in growth of the fruit corresponding closely to the time when the readily available soil moisture is exhausted. On the other hand, apparently, no increase results from adding water to those treatments in which the moisture content is above the permanent wilting percentage. The belief that by irrigating shortly before harvest, one can make the fruit absorb extra water and thus markedly increase in size, is not borne out by these experiments, nor by those with peaches.[1]

Soil Moisture and Size of the Fruit.—Since prunes are sold on the basis of size, the grower wishes the trees to produce, as far as possible, fruits of desirable size. With peaches, plums, apples, and apricots, hand thinning reduces the crop so that the fruit remaining will grow to marketable size. French prunes, however, are not thinned and consequently, in years of large crops, may run to small sizes. The question naturally arises as to the effect of irrigation on size. Obviously, the average size of fruit is greatly influenced by the amount on a tree, so that it may be

small one year and large the next. The only consistent effect, apparently, of irrigation upon the size of individual fruits is that the unirrigated trees, for the past three years, have produced the greatest percentage of small-sized dried prunes.

In 1932 the average sizes of the dried fruits follow the same order as those of the measured fresh fruits, which show significant differences between certain treatments. The proportion of the various sizes from a given treatment, together with the total yields, may affect the returns to the grower. For example, using the yields and prices received in 1932, although the average yields per tree in treatments A, B, and C were nearly equal, the gross returns from A were $68.40 an acre; from B, $67.92; from C, $58.44. The relatively low gross returns from C were largely because of a high proportion of small-sized fruit in that treatment. The gross returns from D, with low yields and small-sized fruit, were only $41.58.

Since it required extreme differences in soil-moisture conditions to produce relatively small differences in size of prunes, it is reasonable to expect that fluctuations from the field capacity to about the permanent wilting percentage will have no effect on the size.

Drying Ratios of Fruit.—French prunes are seldom sold fresh, but are generally dried or dehydrated. According to popular opinion, irrigated fruit contains more water than unirrigated, so that the drying ratio, or the ratio of fresh to dry weight should be greater for the irrigated fruit than the unirrigated. During the last six years of the experiment, however, the results, despite considerable variation in the drying ratio from year to year, show no marked differences between treatments. In other words, irrigation did not materially change the drying ratios. Furthermore, none of the irrigation treatments appeared to induce cracking of the fruit. Considering the severe conditions to which some trees were subjected, one might expect greater differences. Similar results were secured with Muir peaches[1] and with Thompson Seedless grapes.[2]

Soil Moisture and Quality of the Fruit.—The sugar and acid contents during the last three years of the experiment likewise show no consistent differences between treatments. Nichols and Reed,[3] as previously indicated, concluded that the specific gravity of prunes is a measure of quality. In the present experiments it showed only small differences between treatments. Evidently where readily available moisture in the top 6 feet of soil is not exhausted until midsummer, irrigation had very little effect on quality, as measured either by the sugar content of the fresh fruit or by the specific gravity of the dried product.

In the last six years of the experiment, when the soil was wet to a depth of 6 feet at the beginning of each growing season, the permanent wilting percentage was reached about the same time in the 0 to 3 and the 3 to 6-foot depths. These results, however, might not have been obtained if the moisture properties of the first and the second 3 feet of soil had differed more markedly than in this orchard. As the results show, the prune trees were influenced by the soil moisture in the upper 6 feet; and the presence of available water below this depth did not prevent wilting, even though the extraction curves indicate the presence of some roots at this depth.

Extraction of Soil Moisture by the Trees.—Records show that the soil moisture in the 6 to 9 and 9 to 12-foot depths was generally higher in C than in B during most of the growing season. The rainfall on the average did not wet the soil more than about 6 feet in the B treatment, but penetrated more deeply in C, because of moisture remaining from irrigation during the previous fall. Treatment C had readily available water below 6 feet at all times; but B lacked it, in the 6 to 9-foot depths, at certain periods, as shown by the soil-moisture records of the last six years of the experiment. In treatment C, despite readily available moisture present below 6 feet, the growth and yields of the trees were smaller than in B, though not significantly so. These results indicate that yields and growth of trees are principally influenced by the soil-moisture condition in the top 6 feet and that the moisture below this depth is relatively unimportant under Davis conditions. Evidently, wetting the soil below 6 feet by winter irrigation is unnecessary. This conclusion agrees with previous studies of peaches and prunes.[1, 4] In years of deficient rainfall, however, winter irrigation may be desirable to wet the soil to a depth of 6 feet, or to the full depth where there is an impervious layer less than 6 feet below the surface.

The soil-moisture curves showing the rate of extraction by the trees (figs. 5, 6, 7, and 8) are essentially straight lines, indicating a pronounced change in direction when the soil moisture is reduced to about the permanent wilting percentage. The extraction of moisture, after reduction to the permanent wilting percentage, does not entirely cease, as is shown in the curves. The uniform rate of extraction is especially evident early in the season. The curves sometimes descend more rapidly immediately after irrigation than later, because the samples were taken before the soil had drained to its field capacity. The substantially uniform extraction rate between the field capacity and the permanent wilting percentage indicates that prune trees can obtain water with equal facility from the field capacity to about the permanent wilting percentage. Previous experiments with prunes, peaches, and grapes

gave similar results.[4, 1, 2] Since the needs of the tree seem to be supplied by soil moisture between the field capacity and the permanent wilting percentage, additional water, applied while the moisture contents are between these limits, will presumably not influence the responses of the trees. In practice, of course, one may have to begin irrigation before the readily available water is exhausted, in order to cover the orchard before any tree shows evidence of wilting.

Mature prune trees at Davis, starting the season with the upper 6 feet of soil wet to the field capacity, generally reduced the moisture in this depth to about the permanent wilting percentage during the period from the middle of June to the first part of July. Ordinarily, according to these results, mature prune trees on soils essentially similar to those at Davis, with similar rainfall, need not receive the first irrigation earlier than about June 15.

The soil-moisture curves show the approximate length of time that moisture is available after each irrigation, at Davis. Ordinarily, in midsummer, an irrigation that wets the soil to a depth of 6 feet is exhausted in about six weeks. To maintain the supply of readily available moisture, as previously stated, the first irrigation is necessary between the middle and the last of June. A second irrigation is required about August 1; and a third about September 15 or shortly after harvesting. When the readily available soil moisture was exhausted before water was applied, about 8 acre-inches of water per acre, exclusive of losses, was required to wet the soil to a depth of 6 feet at each irrigation. Because of soil variations, some parts of the orchard required less, others more. When the available water supply was not yet exhausted, less than 8 acre-inches per acre would wet the soil to a depth of 6 feet.

The average seasonal application of water to treatment A during the last five years was 25 acre-inches per acre. By using this amount, together with rainfall, a supply of continuously available moisture was maintained throughout the year; and less would probably have sufficed, since sometimes the soil was moistened to a depth greater than 6 feet, and at times water was applied before the readily available supply was exhausted.

Constancy of the Permanent Wilting Percentage.—The soil-moisture contents in the top 6 feet, at which there was a marked decrease in the rate of extraction of moisture, which corresponds to the permanent wilting percentage, were approximately equal each year. This fact emphasizes the constancy of the permanent wilting percentage. Trees allowed to wilt for portions of the growing season during each of the last five years of the experiment, nevertheless did not lower the permanent wilting percentage in spite of these repeated wiltings, and were, from this

standpoint, no more drought resistant at the end of this period than at the beginning. Prune trees, as previously pointed out, are drought resistant in being able to produce fair crops despite long periods of drought during the last part of the growing season; but this ability seems to be inherent in the trees, and not acquired during the experiment.

The results of this ten-year study indicate how readily available moisture may be maintained during the growing season without undue waste and often with a considerable saving in costs.

Outline of Economical Irrigation Practice for Prune Orchards.—The following suggestions on prune trees will serve, with some modifications, for irrigation practice in most districts in California where prunes are grown. As previously pointed out, mature prune trees at Davis usually exhaust the readily available soil moisture in the top 6 feet between the middle of June and the first week in July. Inasmuch as the 0 to 3 and the 3 to 6-foot depths of soil at Davis reached the permanent wilting percentage at approximately the same time, with a similar soil, common pigweeds or other broad-leaved weeds, though shallower-rooted than the trees, will indicate when the readily available moisture is exhausted.

Another reason for using a few such broad-leaved weeds as indicator plants is that they show wilting more distinctly than the prune trees: ordinarily their leaves droop temporarily during the afternoon when readily available moisture is nearly exhausted. Of course trees are likewise affected, but if this soil-moisture condition is not allowed to persist for more than a few days, the effects are not serious. When the leaves do not recover turgidity during the night, but remain wilted, the soil moisture is reduced to about the permanent wilting percentage.

Because the moisture properties of soil are variable, nearly all orchards have some areas from which the readily available water is exhausted soonest. By noting the first signs of drooping in the weeds in these areas, the grower still has a few days in which to prepare for irrigation. Where only small heads of water are available, however, some trees may be decidedly affected before they are irrigated. By observing the indicator weeds, for a season or two, one can generally irrigate so as to maintain readily available moisture at least throughout a major portion of the orchard.

Irrigation before the readily available moisture is exhausted replenishes the supply sooner than necessary. Of course, if this is done, less water is needed to wet the soil to a depth of 6 feet; but, during the season more frequent irrigations are necessary, with more waste than if watering were delayed until the top 6 feet was almost dry.

Though the trees evidently are not affected by irrigation before the readily available moisture is exhausted, they may be injured if the soil

becomes water-logged and its oxygen supply is reduced by too frequent irrigations. Furthermore, leaching may take place if the applications of water are too frequent or too large.

The readily available soil moisture from the first irrigation, under Davis conditions, will usually be exhausted in about six weeks, necessitating a second irrigation between the first and the middle of August. If the grower wishes to maintain readily available moisture until late fall, a third irrigation is necessary, in September.

At Davis about 8 acre-inches per acre would moisten 6 feet of soil, when the readily available moisture was exhausted. As a matter of expediency, some growers apply only enough water to wet about 3 feet of soil in the fall. Probably, under climatic conditions similar to those at Davis, the total water required by mature prune trees would not be affected by the soil type. Soils holding comparatively little readily available water will require more frequent but smaller applications than those at Davis. On the other hand, soils retaining much readily available moisture may be irrigated less often, with more water at each application, than at Davis. The availability of soil moisture is discussed in a previous publication.[7]

Sometimes the grower must dispense with an irrigation. Which, then, may best be omitted? According to these experiments, a drought period of two or three weeks in midsummer reduced yields more than a much longer dry period in the fall, and indicated that the safest irrigation to omit is the last one.

SUMMARY

After four years of differential irrigation treatment, the trees in the continuously moist treatment averaged largest, those in the intermediate treatments next, and those in the unirrigated treatment smallest. This order was maintained throughout the remainder of the ten-year period. The differences were not always statistically significant.

The reason that differences were not apparent earlier in the experiment may be because the soil was not permeated with roots.

The growth and yields were affected as much by the lack of readily available moisture for a relatively short period in midsummer as for a longer period late in the growing season.

The growth of prune trees in all treatments was materially affected by the amount of crop produced and by severe red-spider infestation.

No winter injury was evidenced during the ten-year period, even by the trees irrigated late in the fall.

During the first five years of the experiment, no differences in yields could be attributed to the irrigation treatment.

After five years of differential irrigation treatment, the cumulative yields from the trees in the continuously moist treatment averaged largest; those from the intermediate treatments, next; and those from the unirrigated treatment, smallest. Likewise, the average annual yields followed in the same order.

Sizes of both fresh and dried prunes were not influenced by the amount of readily available moisture in the soil, but were affected by the lack of it during the growing period of the fruit.

Decisive differences in growth of trees, yields, and fruit size did not appear unless the soil moisture was reduced to about the permanent wilting percentage during the growing season, although significant differences were not always obtained even then.

Differences in specific gravities, sugar and acid contents, and drying ratios of French prunes from the different irrigation treatments were surprisingly small.

The initial size and rate of growth of prunes early in the growing season were essentially the same regardless of the irrigation treatment of the previous growing season.

Neither blossoming time nor the beginning of growth was affected by the irrigation treatment of the previous growing season.

French prunes ordinarily attained full size from three to four weeks before the usual harvest time.

Lack of readily available soil moisture during the fruit growing period seriously affected the growth rate of the fruit, which subsequently, even though the trees were irrigated later in the season, remained smaller than in the continuously moist treatment.

After the trees were about ten years old, the permanent wilting percentage in the 0 to 3 and the 3 to 6-foot depths was reached at about the same time, whenever the soil was wet to a depth of 6 feet at the beginning of the season or after an irrigation.

The permanent wilting percentages of each plot, indicated by the distinctly changed slope of the moisture extraction curves and also by the general appearance of the trees, agreed from year to year.

Though mature prune trees at Davis were usually affected when the soil moisture was reduced to about the permanent wilting percentage in the top 6 feet, readily available moisture below this depth did not keep them from wilting.

After ten years the unirrigated trees did not reduce the soil-moisture content at permanent wilting lower than at the beginning of the experiment. In this sense they were no more "drought resistant" at the end than at the beginning.

Mature prune trees at Davis exhausted the readily available soil moisture in the top 6 feet, in years of normal rainfall, some time between the middle of June and the first week in July. In midsummer, after an irrigation, they exhausted it in about six weeks.

The prune trees obtained moisture as readily near the permanent wilting percentage as to the field capacity.

The results obtained in these experiments indicate that applying water to a prune orchard shortly before the moisture content of the top 6 feet of soil is reduced to the permanent wilting percentage constitutes good irrigation practice.

ACKNOWLEDGMENTS

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A SIXTEEN-YEAR EXPERIMENT ON APRICOT PRUNING

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A SIXTEEN-YEAR EXPERIMENT ON APRICOT PRUNING[1,2]

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APRICOT PRUNING is one of the important orchard operations in southern California. The pruning is usually done during the winter months. The trees, owing to their vigorous habit, grow rapidly in response to a definite system of pruning (fig. 1).

TABLE 1

CLIMATOLOGICAL DATA FOR 1930 AT THE CITRUS EXPERIMENT STATION*

	Precipitation, inches	Mean temperature, deg. Fahr.	Actual hours of sunshine	Per cent of possible sunshine	Relative humidity, per cent	Evaporation from open pan, inches	Mean daily wind movement, miles
January	5.64	49.8	167	53	74.6	1.9	106
February	0.44	56.9	258	84	69.7	2.7	87
March	3.67	56.5	235	78	68.5	3.8	118
April	0.70	62.2	313	86	72.5	5.3	87
May	3.63	60.1	240	61	65.9	5.6	107
June	0.00	69.5	224	71	69.0	7.7	91
July	0.00	76.9	330	75	60.2	9.5	95
August	0.00	72.3	288	75	72.0	8.5	87
September	0.00	68.8	260	72	75.0	6.2	81
October	0.79	64.4	267	77	66.7	4.0	97
November	1.01	59.8	231	74	66.2	4.2	122
December	0.47	50.3	225	73	58.5	2.9	104

*Riverside, California. Latitude, 34° N.; elevation, 1,046 feet.

To ascertain the effects of certain types of pruning, the experiments described herein were conducted over a period of 16 years in an orchard at the Citrus Experiment Station at Riverside, California. The orchard was on land classified as Ramona loam which had formerly been used for grazing and for grain production without irrigation. The location is representative of a large area in southern California occupied by apricot orchards. According to figures kindly furnished by agricultural commissioners, the apricot orchards of Riverside and San Bernardino counties covered 6,997 acres in 1931. About 14 per cent of the acreage was classed as nonbearing.

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[2] Paper No. 282, University of California Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

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CLIMATIC CONDITIONS

The locality in which this experiment was conducted has a short rainy season in the winter and hot dry summers, during which the evaporation rate is high. A detailed account of the meteorological conditions cannot be presented here; however, table 1, which shows data for 1930, will give the reader an idea of a sample year. The yield of fruit may be lowered



Fig. 1.—An apricot tree pruned to form a vase-type tree. Photograph taken 7 years after the tree was planted.

by extreme temperatures during or after the blossoming period. Flowers or small fruits are sometimes injured by hot, desiccating winds before the foliage is well developed. The maximum temperature (table 2) obtained from instruments in or near one particular orchard, was above 72° F on 8 days in March, 1925, and on 10 days in 1931. Low temperature caused some damage to the fruit in 1931 but none was observed in other years. Frost injury was probably one of the causes for a high degree of variability in the yield in that year.

During May the weather is generally cool and often cloudy, changing rather abruptly early in June to cloudless days on which the maximum temperature may be 95° F. Toward the end of June the temperatures may rise daily above 100° F. This rapid transition is often a detriment to the trees and the fruit crop because the fruit is sunburned where it is exposed to strong sunlight during the long days of June. When ripe, the surface of the sunburned fruits is often badly cracked, decreasing the

TABLE 2

Temperatures in the Blossoming Period*

Year	Date of full bloom	Number of days in which maximum temperature was above 72° F.	Number of nights in which minimum temperature was below 32° F.	Number of nights in which minimum temperature was below 30° F.
1921	March 5	1	0	0
1922	March 25	0	1	0
1923	March 28	5	0	0
1924	March 1	3	0	0
1925	March 1	8	0	0
1926	March 8	5	0	0
1928	March 1	2	0	0
1929	March 15	4	2	0
1930	March 10	5	0	0
1931	March 3	10	2	1

* The records for 1927 were lost soon after they were taken.

value of the crop. Apricots in exposed situations frequently bear a blemish designated locally as "fog mark," which is characterized by irregular russetted areas covering a large proportion of the surface. On account of this "fog mark," fruit must generally be sold at a reduced price. Fruit produced in the interior part of the tree is generally free from this blemish, but that which is produced in the upper part of the tree is seriously blemished.

These climatic factors are mentioned because their effects on the trees have a bearing on the pruning practices. Any means of training the trees which produces foliage to shade the fruit is a decided advantage to its quality in the climatic conditions prevailing in southern California.

An effort was made to maintain the moisture content, as well as to give the orchard good care in other ways. The soil was sampled in definite areas to a depth of 4 feet at frequent intervals, usually preceding and following an irrigation.

During the autumn and early winter the rainfall is usually light. Storms giving a total precipitation of less than 0.5 inch do not yield enough water to penetrate to the root zone in dry soil. Unless the rain-

fall in these months is supplemented by irrigation, the apricot trees ar in danger of a serious water deficit.

The cultural conditions were satisfactory during the course of th experiment; at least they were as uniform as could be maintained unde

BLOCK A	[1]	1	2	3	[2]	4	5	6	[3]	7	8	9	[4]	10
BLOCK B	8	[1]	9	10	1	[2]	2	3	4	[3]	5	6	7	[4]
BLOCK C	[1]	5	6	7	[2]	8	9	10	[3]	1	2	3	[4]	4
BLOCK D	2	[1]	3	4	5	[2]	6	7	8	[3]	9	10	1	[4]

Fig. 2.—Plan of orchard used for pruning experiments. Numbers in brackets indicate control plots in which trees were pruned as little as possible. Numbers without brackets indicate plots to which reference is made in the text.

field conditions. Fertilizing materials were not added. The trees were sprayed annually after the winter pruning to control insects and parasitic fungi.

SCOPE OF THE INVESTIGATION

It is a bit difficult to visualize today the acute condition of the pruning problem in southern California from 1914 to 1919. Many growers did not realize the necessity for regular pruning of apricots. In some districts nearly all the pruning was done by pruning contractors, each of whom had his own system of tree pruning. These systems often differed

radically from each other. Admittedly some were better than others, but the horticulturist was generally at a loss in deciding on their relative merits. Discussions of the pruning problem were frequent (and acrimonius) but satisfactory conclusions were less frequent. Under the crossfire of opposing arguments the apricot grower was apt to award the contract to the lowest bidder, with certain mental reservations about the entire problem of pruning.

The experimental work to be related here was planned during this period of uncertainty and dissension, to obtain some information under conditions that would exclude the more glaring inequalities of soil and cultural conditions which prevail when one attempts to compare growth or yields of different orchards. The experiment was designed to yield information on the relation of various types of pruning to the growth of tree and fruit production.

This experiment differs from many others in that the orchard was planted for the purpose of conducting this particular work and continued until after the trees came into full bearing.

The orchard consisted of 280 trees of the Royal variety. The trees were planted 20 x 24 feet apart in the orchard. There were 14 plots of 20 trees, each of which consisted of 4 subplots of 5 trees. Every fourth subplot was a control plot in which the trees were not pruned, except as was necessary to allow the passage of implements of cultivation or to remove broken branches. A diagram of the plot arrangement is shown in figure 2.

Annual records were taken of: (1) area of cross section of tree trunk (computed from the circumference measured at a marked height), (2) weight of wood removed by pruning, (3) weight of fruit produced, and (4) average number of fruits per pound.

THE DIFFERENTIAL PRUNING TREATMENTS

The trees were planted in February, 1916. The differential pruning began in January, 1918, although several more years passed before the types were well established. The first commercial crop was produced in 1922.

The types of pruning employed fall into three general classes: Heading back in winter and thinning in summer; heading back in winter; and lightly pruned in winter (long pruning).

A detailed description of the types follows.

1. *Central-Shaft (Modified Leader) Type, Heavily Pruned in Summer and Winter.*—One limb near the center of the tree was allowed in the early years to grow higher than the scaffold branches (fig. 3). A central limb was chosen if possible; otherwise one of the scaffold limbs

(modified leader) was developed higher than the others. Each winte these trees were pruned to develop a framework, to head back the shoot produced in the preceding season, and to remove superfluous branche as in the case of other plots. In addition they were pruned lightly i



Fig. 3.—Central-shaft type before pruning. Tree D–6–1, January, 1931. In the preceding season this tree produced 319 pounds of fruit which averaged 12 fruits per pound.

July each year after the fruit had been harvested. No shoots were headed back at this time, but new growth was removed, especially from the top of the tree, to admit more light. The shoots removed were from 2 to 5 feet long. The weight of the leafy shoots removed was not determined inasmuch as it was not comparable to the weight of brush removed at the winter pruning. The trees in this plot were very severely pruned during

the first 6 years of the experiment, but subsequently there was less difference between them and the next type. As the trees grew in size it was difficult to maintain the central leaders because the original central leader sometimes failed to maintain a vertical position. In a few instances it was necessary to start a new leader and to make the original



Fig. 4.—Central-shaft type after pruning. Tree D–6–1, January, 1931. This framework distributes the bearing wood on the larger limbs in a way that avoids sunburned fruit.

leader a subordinate branch. The dense top formed by the central leader intercepted light, and was later detrimental to the lateral limbs.

2. *Central-Shaft (Modified Leader) Type, Moderately pruned in Summer and Winter.*—There was no significant difference between this and the preceding type except in the amount of wood removed. During the first 6 years the pruning was less severe than that of type 1.

3. *Vase Type, Heavily Pruned in Summer and Winter.*—This type of tree is found in nearly all the apricot orchards in the southern part

of the state (figs. 1 and 5). The young tree was trained to 3, 4, or main scaffold limbs, and these were pruned to develop an open vas form. Above the height of 6 feet secondary branches were left, exten



Fig. 5.—Vase type before pruning. Tree B–8–1, January, 1931. In the preceding season this tree yielded 309 pounds of fine fruit, averaging 9 fruits per pound.

ing the framework of the tree outward in a radial direction as far as was consistent with the mechanical strength of the framework. The heavy pruning done when this type of tree was young had a detrimental effect upon the fruit production of that period.

4. *Vase Type, Moderately Pruned in Summer and Winter.*—The difference between this and type 3 lies in the severity of the pruning. As an illustration we may say that the tips of the main scaffold limbs after pruning were between 6 and 8 feet from the ground at the



Fig. 6.—Vase type after pruning. Tree B–8–1, January, 1931. The new growth was cut back to stubs 8 to 12 inches long. A large part of the fruit is produced on slender, pendant laterals. A picture of this tree taken 8 years earlier is shown in figure 1.

end of the third year. When 14 to 18 inches of the preceding season's wood was left on the heavily pruned trees of plot 3, 28 to 40 inches was left on plot 4. The plots which were pruned twice a year generally received less pruning in the winter than types 5–8, which were pruned only in the winter (table 3). The total weight of the prunings from

TABLE 3

THE AVERAGE WEIGHT OF WOOD REMOVED BY THE WINTER PRUNING IN POUNDS PER TREE*

Plot No.	1922	1923	1924	1925	1926	1928	1929	1930	1931
Trees pruned summer and winter									
1	59.5±3.64	39.1±2.23	50.4±3.20	67.7±3.67	43.6±3.92	39.0±3.28	45.0±4.78	11.1±0.87	20 4±2.04
2	62.2±2.56	35.6±1.55	52.1±1.67	79.2±2 68	57.6±2.13	42.0±2.57	39.6±2.40	13.1±1.04	19.5±1.50
3	62.9±1.72	44.1±2.18	49.0±1.46	80.5±2.23	56.6±2.25	36.3±2.27	43.8±2.36	10.8±0.88	20.1±1 12
4	65.5±2.15	39.1±1.63	45.8±1.16	74.2±2.11	51.3±1.42	37.6±2.12	48.8±2.72	11.9±0.67	19.9±1.31
Trees pruned in winter									
5	71.6±2.76	49.9±2.32	66.0±2.36	80.5±2.41	80.2±2.74	60.6±3.65	84.4±4.48	37.8±2 50	59 8±4 67
6	72.7±2.31	45.1±1.85	68.6±2.49	83.5±2.61	76.0±2.45	65.0±4.02	87.0±4.49	38 8±3.92	53 5±2 67
7	78.3±2.35	62.6±3.46	79.3±2.88	84.1±3.17	83.2±2.55	68.7±3.57	89.6±5.04	42.2±3 92	65.7±4 09
8	80.4±3.00	54.2±3.51	86.9±4.15	110.2±4.68	91.1±3.18	83.8±6.13	123.7±9.02	52.2±5 27	78 0±5 41
Trees girdled									
9	70 6±3.56	40.7±2.72	71.7±3.45	84 4±3 03	78.8±3 22	54 0±3 03	75.5±5.74	29 3±1 91	54 8±3 64
Trees not headed back, moderately pruned									
10	41.9±2.52	53 5±4.28	91 4±3.74	64 5±2 02	36 1±2 06	20 9±1 73	35.1±3 04	18 5±1 45	32 1±3 00
Control trees									
A (1), B (2), C (3), D (4)	57.9±2.98	9 5±1.60	24.2±2 19	37 5±2 98	15 9±2 13	52 6±3 18	10 3±0 87	4 9±0 66	20 8±1 83

* The records for 1927 were lost soon after they were taken.

types 1–4 was probably not much less, however, than that of the prunings from types 5–8, except in the later years.



Fig. 7.—Tall vase type before pruning. Tree C–10–3, January, 1931. This type was thinned but not regularly cut back. When it was necessary to shorten a limb it was cut back to a lateral branch. In the preceding season this tree produced 239 pounds of fruit which averaged 16 fruits per pound.

5. *Central-Shaft (Modified Leader) Type, Heavily Pruned in Winter.*—Trees pruned by this method were essentially like those of type 1, except that there was no summer pruning.

6. *Central-Shaft (Modified Leader) Type, Moderately Pruned i Winter.*—This type was like type 2 except that it was not pruned in sum



Fig. 8.—Tall vase type after pruning. Tree C–10–3, January, 1931. This type is not well suited to the hot interior valleys of southern California because the tree produces much of its fruit on the tall arched limbs where it suffers from sunburn.

mer; and like type 5 except that it was not so severely pruned. Figures 3 and 4 show one of these trees at the end of the thirteenth year. The growth of the central shaft in this tree was retarded by the lateral pres-

sure of the surrounding scaffold limbs. The bases of the lateral limbs choked the central shaft because of their more rapid growth.



Fig. 9.—Unpruned type. Tree A–(1)–5, January, 1931. The photograph was taken after a broken limb had been removed. The unchecked growth has formed a dense top which contains much dead wood. The upper branches show the usual tendency to grow toward the prevailing wind. In 1930 this tree produced 441 pounds of fruit, averaging 14 fruits per pound.

7. *Vase Type, Heavily Pruned in Winter.*—This type was like type 3 except for the time of year at which the trees were pruned.

8. *Vase Type, Moderately Pruned in Winter.*—This type was lik type 4 except for the time of year at which the trees were pruned (fig 5 and 6).

9. *Vase Type, Girdled, and Moderately Pruned in Winter.*—Th large limbs were girdled in 1922 and in 1927. The pruning was like typ 8 except for the girdling by removal of a very narrow ring of bark i the early summer of the years noted. The girdling was harmful to th trees. Some of the wounds never healed and large limbs died as a result

10. *Lightly Pruned (Long Pruning) Type, Lightly Pruned i Winter.*—Trees pruned by this plan were headed back for the first years, and then were trained in the form of a tall vase whose scaffol limbs were thinned but not headed back. The tendency for apricot branches to bend horizontally was counteracted by heading back to a vigorous vertical lateral. This was designated as a type of light pruning, but from time to time large limbs broke and had to be removed, resulting unintentionally in rather heavy pruning. The trees figs. 7 and 8) were taller than those of any other type and difficult to prune. Side branches were frequently removed from the scaffold limbs to keep the top thinned out. This was a close approximation to the system once designated "long pruning."

Control Plots (Unpruned).—Every fourth subplot was used as a control from which yields and size of tree for intervening plots were computed as percentages, as will be explained later. The control trees grew rapidly and produced large crops of fruit; gradually the tops became very dense (fig. 9) and the fruit laterals in the lower interior of the tree died. As a result the fruit was mainly produced in the top of the trees on long, slender branches. Main limbs sometimes broke, even though artificially supported. Their removal constituted a form of pruning. Low-hanging branches were removed to permit the use of implements of cultivation. The varying amounts of wood removed are shown in table 3.

RESULTS OF THE EXPERIMENTS

THE EFFECT OF SYSTEMATICALLY HEADING BACK THE NEW GROWTH

The apricot tree produces its fruit on short laterals arising from older shoots. The production of these laterals and the perpetuation of their vigor becomes, therefore, one of the chief concerns of the horticulturist.

By far the best fruit was produced on short pendent laterals borne on the larger branches (figs. 10 and 11). Year after year these small shoots yielded fruit of good quality. When they were pruned off, after having lost vitality, the cut was not made so close to the main limb that the ac-

cessory buds near the base of the lateral were destroyed, and a new fruiting lateral frequently grew after an older shoot had been removed. The annual heading back in the dormant season increased the vigor of the fruiting laterals and prolonged their productive periods. When lightly pruned, as in plot 10 or in the control plots, opposite results were obtained, i.e., the few fruiting laterals that appeared were short-lived.



Fig. 10.—Interior of central-shaft type. Tree A–2–1, January, 1924. Fruiting laterals had been well developed.

The year-old, upright shoots in the upper part of the trees in plots 1 to 9 inclusive, were frequently headed back so severely that not more than 20 per cent of the mature shoot remained. Many commercial apricot orchards in southern California are pruned as severely with no detrimental effects upon the trees.

THE MECHANICAL FRAMEWORK OF THE TREE

The mechanical framework of the tree is largely a question of orchard technic, but it has a rightful place in a discussion of pruning methods. The ten types of pruning included four types of framework, viz., central-shaft, vase, tall-vase (plot 10), and a dense top containing many slender branches (controls), The only types which gave good results were the first two, and between them there is little choice. Both form good spreading frameworks and produce satisfactory quantities of fruit.

As a precaution, wire ties were generally installed in all the trees by

means of which one limb tended to counterbalance the pull of a limb o
the opposite side of the tree. A strong screw eye was turned into th
upper (inner) side of a limb approximately 8 feet above the groun



Fig. 11.—Interior of central-shaft type. Tree A–2–1, July, 1922. This illustrates the production of fruit on interior laterals. The yield for the tree was 319 pounds. The average number of fruits per pound was 13.3.

The end of a piece of 14-gauge wire was put through the screw eye and twisted on itself to make a strong loop. The other end of the piece of wire was similarly looped and twisted through a screw eye in another limb on the opposite side of the tree, drawn tight, and twisted. In case there were several limbs in the tree needing support one end of each stay

wire was tied into a central iron ring, thereby obtaining a little better distribution of the load. The supporting wires are more economical than props and offer no obstacles to cultural operations.

The framework of long-pruned trees (plot 10) suffered breakage principally on account of the greater length of the scaffold limbs. The amount of labor required to care for trees in this plot was much greater than in the others on account of the production of fruit on the long,

TABLE 4

AVERAGE WEIGHT OF WOOD REMOVED PER TREE AT THE ANNUAL WINTER PRUNING COMPARED WITH FRUIT PRODUCED

Year	Plots 1-10		Plots 5-8	
	Wood removed	Yield per tree	Wood removed	Yield per tree
	pounds	*pounds*	*pounds*	*pounds*
1922	67	172	76	163
1923	46	39	53	47
1924	66	86	75	86
1925	81	124	89	126
1926	65	67	82	59
1927	....	167	....	168
1928	52	223	70	215
1929	66	263	96	246
1930	28	250	44	257
1931	44	133	65	110

curved branches. Whether the fruit was removed at an early stage with a padded pole or was picked at maturity, the work involved added expense.

The maximum losses from defects in the mechanical support of the tree were in the control trees which never had any branches removed from the tops unless broken (fig. 9).

RELATIONS BETWEEN THE AMOUNT OF WOOD REMOVED AND THE YIELD OF FRUIT

For the initial discussion, the types of pruning are disregarded and only the severity of pruning considered—judging it from the weight of wood removed. The reliability of this criterion is due to the fact that all, or practically all, of the wood removed consisted of shoots which grew during the previous season. It would be more accurate to express this quantity as a percentage of the weight of the entire tree, but that method is obviously impossible. Reference to the second column of table 4 shows that there were four years in which the average weight of wood removed was substantially the same. Since the trees were larger in 1929 than in 1922, the removal of 67 pounds of wood in 1929 was relatively less severe than the removal of an equal weight in 1922. The same will apply

TABLE 5

AVERAGE YIELDS OF FRUIT IN POUNDS PER TREE

Plot No.	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Trees pruned summer and winter										
1	140.0±4.8	39.8±3.3	82.4±4.8	95.6± 3.2	76.8± 5.5	147.0± 5.5	204.5± 7.6	202.0±11.9	276.3± 8.2	102 0±14.7
2	190 6±8.7	28.3±2.8	114.5±5.0	109.0± 4.3	111.5±10.3	173.3± 9.0	267.8±10.4	212.0±12.1	299.0±10.4	89.0±13 1
3	141.5±3.7	45.0±3.7	70.0±3.4	128.5± 5.0	67.5± 8.6	178.5± 8.3	226.5± 6.5	288.0±12.1	237.0±14.6	190 0±13.6
4	183.2±5.8	28.0±2.0	70.3±4.3	139.2± 4.9	73.7±11.8	179.4± 7.8	260.0±14.8	259.0±12.9	298.0±13.9	119 5±10 9
Trees pruned in winter										
5	139.5±4.9	47.5±2.2	92.0±3.3	117.5± 3.1	70.5± 6.0	153.8± 6.6	226.3± 6.5	215.0± 8.6	238.0±11.1	80 0± 7.2
6	166.5±8.5	45.3±3.0	74.5±5.5	135.5± 5.2	62.5± 8.4	159.8± 8.7	217.0± 9.5	250.0±12 0	244 0±12 0	102 0±10.9
7	129.5±7.4	47.2±3.3	76.1±5.8	107.8± 4.0	50.5± 3.7	149.4± 7.3	182.0± 8.9	240.0±12.2	217.0±14.5	123 0±10 9
8	216.9±6.2	48.2±5.2	104.5±4.0	144.5± 4.3	49.5± 2.6	210.2± 8.5	234.5± 9.3	280.0±12.9	303 0±14.6	126.0±11 9
Trees girdled										
9	176.5±5.9	37.4±2.8	90.0±4.6	122.5± 4.6	52.5± 6.6	155.3± 7.4	143.3± 8.9	276.0±11.7	118 0±11.6	169.0±11 4
Trees not headed back, moderately pruned										
10	237.5±8 6	21.8±1.2	81.5± 5.4	139.5± 5.3	56.5± 5.4	160.5±12.5	262 0±12.4	403.0±22.9	269 0±18.1	232 0±22 2
Control trees										
A (1), B (2), C (3), D (4)	259 5±9 2	21.5± 1.4	156 0±8.6	215.0±13.4	77.9± 9.7	294 0±13.1	335 0±24 6	414 0±21 3	224 0±28 3	258 5±16 5

to 1924 and 1926. The yields of fruit for these four particular years varied from 67 to 263 pounds. It would be obviously unsafe on this basis to make any assertions about the relation of pruning to fruit yield.

It is evident that the severity of pruning (measured by the weight of wood removed per tree) had no general relation to the quantity of fruit produced in the following summer.

TABLE 6

PLOT YIELDS EXPRESSED AS PERCENTAGE OF CONTROLS

Plot	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	Averages
Trees pruned summer and winter											
1	54	157	55	53	132	50	70	49	181	41	84
2	74	129	60	51	137	66	82	53	156	39	85
3	61	202	42	61	93	68	81	76	140	72	90
4	77	135	41	72	88	66	104	69	240	46	94
Trees pruned in winter											
5	53	211	50	59	85	59	70	55	148	33	82
6	62	205	40	67	68	59	66	63	144	41	82
7	48	215	47	52	90	53	59	63	146	47	82
8	77	212	62	66	92	72	76	72	200	48	98
Trees girdled											
9	64	168	57	61	91	51	52	71	89	63	77
Trees not headed back, moderately pruned											
10	93	101	55	62	127	57	99	101	195	90	98

YIELDS FOR THE TEN-YEAR PERIOD

It will be next in order to consider the annual yields of the various plots and to observe whether there are differences which may be related to the types of pruning employed.

The records of yields presented in table 5 are averages of the 20 trees in each plot. They represent the total amount of ungraded fruit from each tree.

Inspection of the data shows that the control plots outyielded the pruned plots in nearly every year. One with a knowledge of southern California conditions might predict such a condition; as a matter of fact, trees of this variety need pruning primarily because they have such a tendency to produce excess amounts of fruit.

The yields of the plots which were pruned are of primary interest to

fruit growers. Plots 4, 8, and 10 were the best in point of quantity of fruit produced, while plots 3, 5, 7, and 9 were low in the quantity of fruit over the ten-year period.

Before attempting to draw any conclusions from the yield records another question must be answered. "How do the yields of the various plots compare with those of the neighboring control plots?" Table 6 shows plot yields as percentages of the nearest unpruned subplots. This method of computation gives a means for correcting for soil variation because each plot is judged by the performance of neighboring control plots.

In general the actual yields were less than the theoretical. The yields were small in 1923 and 1926 and in them the yields of the various plots approximated or exceeded the theoretical yields. The yields were large in 1922, 1927, 1928, 1929, and 1930. In four of these years the yields of the ten plots which received pruning were notably less than the theoretical. The theoretical yields of 1930 constitute a notable exception.

Plots 4 and 10 each held "first place" three times, plot 8 twice, and plots 2 and 7 each once. Plots 4, 8, and 10 were therefore superior plots. On the basis of chance each plot should have been superior only once in the ten-year period.

Reviewing the data on yields it appears that there is a small, but consistent, difference in favor of plots 4, 8, and 10, although the quantity of ungraded fruit produced by the various plots shows no remarkably outstanding differences when the 10 years are considered. The data show that the results of a short-term pruning experiment may be misleading.

THE RELATION OF PRUNING TO QUALITY OF FRUIT

Up to this point the discussion has dealt only with quantity of fruit produced by the plots, but that is, as everyone knows, only a part of the story. Unless the quality of the fruit is satisfactory there is a very restricted market for it and the price is generally low.

The average number of fruits per pound was determined on a sample for each tree and the values for the 20 individual trees were averaged for the 10 plots. The results are presented in table 7. It is apparent that the fruits on the 9 plots which were headed back were larger than on plot 10 or on the control trees. In the last 5 years, when the crops were fairly large, the superiority of the winter heading-back systems was especially evident. There was no particular difficulty in obtaining fruit which had an average number of 10 or 12 per pound. The best sizes were obtained in 1926 when many trees yielded fruit which averaged 6 per pound. The number of fruits per pound on plot 10 exceeded 15 in 5 of the 10 years, and on the control trees in 6 of the 10 years.

TABLE 7

Average Number of Fruits per Pound

Plot No.	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Trees pruned summer and winter										
1	15.3±0.4	9.3±0.2	10.3±0.2	12.5±0.2	8.4±0.4	12 7±0.2	12.0±0.4	13.9±0.4	14.6±0.4	14.4±0.7
2	17.7±0.4	8.3±0.2	10.4±0.2	12.3±0.2	8.5±0.4	13.1±0.2	12.1±0.2	14.7±0.4	15.1±0.4	13.7±0.6
3	15 0±0.6	9.0±0.2	9.8±0.1	13.4±0.2	8.0±0 2	13.3±0.2	11.4±0.2	14 5±0.4	13.0±0.3	16.6±0.7
4	18.0±0.5	8.9±0.2	10.0±0.1	14.1±0.2	7.7±0.3	13.0±0.3	10 8±0 2	13.7±0.4	13.9±0.3	16.2±0 6
Trees pruned in winter										
5	15.0±0.5	8.8±0.2	9.4±0.2	12.5±0.1	8.0±0.4	12.8±0.2	10.9±0 3	13.9±0.4	13.0±0.3	13.4±0.6
6	15.9±0 4	8.9±0 2	9.5±0.2	12.6±0.2	8.3±0.5	12.3±0.2	10.2±0.2	12.6±0.4	12.7±0.3	12.9±0.6
7	13.4±0.5	8.9±0.2	9.1±0.2	12.2±0.2	8.1±0.3	11.9±0.2	9.7±0 3	13.0±0.5	11.6±0.2	13.7±0.4
8	17.4±0.8	7.9±0.2	9.7±0.1	13.0±0.3	7.8±0.5	13.3±0.2	10 3±0.2	13.0±0.3	11.9±0.3	13.4±0.3
Trees girdled										
9	17.6±0.5	9.1±0.2	10.0±0.1	13.1±0.2	8 0±0.2	13.3±0.2	10 6±0.2	15.7±0.4	12.2±0 3	16.1±0 4
Trees not headed back, moderately pruned										
10	28 0±0.7	10.9±0.2	10.6±0.1	15.5±0.2	10 1±0 3	19.4±0.3	12 6±0 2	19.6±0.5	14.3±0.2	21.7±1.0
Control trees										
A (1), B (2), C (3), D (4)	32.7±0 5	12.4±0.2	13.3±0.2	19.3±0.2	10.1±0 3	24.7±0.5	13 4±0.3	21 0±0.7	16.4±0.5	20 3±0 6

Color of the fruit at maturity is one of the standards which determines price, because it usually also indicates the mellowness of the flesh. Most markets prefer apricots which are not too highly colored. A small amount of red diffused through the yellow of the Royal apricot is generally regarded as a good characteristic, but a large amount of red often indicates sunburned fruit. Fruit which grows under the foliage usually develops an even color and the flesh softens uniformly, but on the branches which have scanty foliage the fruits will mature earlier on the exposed side, making them difficult to utilize. If hot weather comes on early, the exposed surfaces of the fruits are killed, the subsequent growth of the fruit produces cracks, and the fruit has no commercial value. The trees which were headed back produced an abundance of new shoot growth on the top which gave the needed protection.

The results obtained from several methods of pruning, therefore, are clearly in favor of one of the methods of heading back, not so much because of differences in the quantity of fruit annually harvested, but because of its size and quality. A type of moderate pruning by which a vase-shaped framework was produced, yielded more than the average amount of fruit, the quality of which was good. The tall-vase (long-pruned) style of pruning is one which may give good results for a few years with young trees but has not been commercially successful when continued for long, at least in the climatic conditions which prevail in the interior valleys of California. An examination of the results will emphasize some of the differences observed.

THE EFFECT OF AN ANNUAL SUMMER PRUNING IN ADDITION TO THE REGULAR WINTER PRUNING

Plots 1 to 4 were annually pruned in the summer as well as in the winter. Within a month after the fruit had been harvested from these plots the vigorous vegetative shoots on the main limbs were removed and the new growth in the top of the tree was thinned. The number of shoots removed amounted to about half the number removed during the entire year. No shoots were headed back in the summer. Unfortunately no accurate record of the amount of material removed could be made. The succulent, leafy shoots were in no way comparable to the woody material removed when the trees were pruned during the dormant period.

The records of the amounts of wood removed at the dormant period show that less was removed from the plots pruned in the summer than from those pruned only during the dormant season, yet the difference between the two is in no way a reliable measure of the weight of wood previously removed by summer pruning. In many cases separate com-

putations were made upon records from plots where summer pruning was applied. The reader may examine them for himself.

The average yields (table 8) give little indication of superiority for either system of pruning.

TABLE 8

YIELDS OF TREES PRUNED AT VARIOUS SEASONS

Year	Average pounds of fruit per tree		
	Pruned in winter	Pruned summer and winter	Unpruned controls
1922	164± 6.9	164± 6.0	254± 4.9
1923	47± 3.6	35± 3.0	22± 0.8
1924	87± 4.8	84± 4.4	165± 4.0
1925	127± 4.2	118± 4.4	210± 4.9
1926	59± 5.6	83± 9.3	89± 6.6
1927	166± 7.8	170± 7.8	275± 7.3
1928	215± 8.8	240±10.3	309±11.4
1929	250±11.0	244±12.3	395±10.7
1930	251±13.1	278±12.1	183±10.6
1931	125±10.4	108±13.1	268± 9.1
Mean	149± 8.19	152± 9.0	217± 7.81

TABLE 9

SIZE OF APRICOT TREES IN VARIOUS PLOTS EXPRESSED AS A PERCENTAGE OF THOSE IN THE ADJACENT CONTROL PLOTS

Plot No.	Year	
	1924	1931
	per cent	*per cent*
Pruned summer and winter		
1	85	85
2	95	90
3	92	96
4	100	98
Pruned only in the winter		
5	87	95
6	86	96
7	87	98
8	104	108
9	93	98
10	98	107

If summer pruning influenced the formation of fruit buds, the production of assimilable substances concerned in the formation of buds and shoots, or the increased resistance to water losses, one might expect to find evidence of a cumulative effect toward the end of a 10-year

period. In the absence of significant differences between the two sets of plots it seems hardly proper to advocate summer pruning of apricots as a practice which will produce greater yields.

The size of the trees of various plots showed a slight effect which may be traceable to the pruning treatments (table 9). We may examine the records for 1924 and for 1931, since these years represent conditions about midway and at the end of the experiment. We notice that 17 of the 20 measurements indicated that the plots which were pruned by the various systems were smaller than their unpruned controls. The differences between the size of pruned and unpruned trees are not great, except in a few cases, but the direction of the differences seems significant.

The sizes in 1931 probably represent the cumulative effect of the pruning. Only two (both summer-pruned) were more than 5 per cent less than their controls. We may conclude therefore that the dwarfing due to pruning was not very great.

SUMMARY

This bulletin discusses the results of a sixteen-year experiment on apricot pruning at Riverside, California. The locality receives its rain during the winter and spring months. During the summer months the temperatures and evaporation rates are rather high and careful irrigation is necessary.

The experiments were conducted on an orchard of 280 trees of the Royal variety. There were 14 plots of 20 trees, each of which consisted of four subplots of 5 trees. The plots were located by a plan which equalized as far as possible the inevitable variations due to soil differences. Ten of these 14 plots were pruned, each by its own system, and 4 were left unpruned for comparisons.

The weight of wood removed by pruning, the size of the trees, the yield of fruit, and the average number of fruits per pound were recorded each year. Thus fairly complete information was obtained about the behavior of apricot trees pruned by various systems when grown in the same orchard. The other cultural conditions were as uniform as they could be made.

The new growth was cut back annually on 9 plots, resulting in the formation of trees which produced fruiting laterals on the main limbs where fruit of desirable commercial quality was produced. The trees of four of these plots were pruned to form central-shaft type trees, and those of 5 plots, to form vase type trees. The trees pruned to form a vase type developed the best mechanical framework. Four of these 9 plots were also lightly pruned in the summer to admit more light to the in-

terior of the tree. The trees in the tenth plot were thinned each winter, resulting in the formation of tall-vase-shaped trees which yielded large crops; but the fruit was inferior in quality.

The largest yields were obtained from 3 plots in which the trees were pruned to a vase shape. Two of these plots were pruned only in the winter; one was pruned each summer in addition to the winter pruning.

The yields of fruit on plots pruned to the central-shaft type were somewhat larger where light summer pruning was also applied. Apparently they were benefited by the admission of more light after the fruit had been harvested.

The size and quality of fruit were best on trees which were systematically headed back. The trees which were pruned by thinning instead of heading back the branches produced large crops of fruit, but it was so small and sunburned that it had no commercial value. The fruit on the unpruned trees was still more inferior in quality. The apricot tree under southern California conditions almost always overproduces unless it is properly pruned. Pruning the trees is to some extent a method of thinning the fruit. The effects of pruning appeared to be more beneficial as the trees became older.

Good quality was not dependent upon small yields as shown by the fact that the plot which had the largest average yields during the ten years, tied for third place on quality.

The trees at the end of the 16 years were healthy, were increasing in size from year to year, and appeared capable of growth for many more years. The largest average size of trees was found in plot 8 which had also the largest average yield; the smallest trees were in a plot which was not pruned. In general, however, the average sizes of pruned trees were slightly less than those of the adjacent control plots.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the assistance of those who have contributed to the prosecution of this work. Among those I wish to thank are my wife, Hannah D. Reed, for her work on the extensive mathematical computations, and my assistant, Mr. J. Enderud, for his faithful work on many phases of the investigation. Mr. Enderud prepared most of the illustrations and graphs for this paper.

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THE DIGESTIBILITY OF BROWN ALFALFA HAY, SESAME MEAL, AND ARTICHOKE SILAGE AS DETERMINED FOR RUMINANTS

A. H. FOLGER

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UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

SUMMARY

The stack-burned alfalfa, commonly known as "tobacco" or brown hay, used in these trials, is approximately equivalent to average alfalfa hay in nutritive value. The excellent results ascribed to it by feeders arise probably from its greater palatability and the consequent fact that the animals consume more of it than of ordinary hay.

The sesame meal available for this trial closely resembles average prime cottonseed meal in feeding value, being higher in all nutrients except the carbohydrates. It contained 35.8 per cent digestible protein and 77.2 per cent total digestible nutrients; while the corresponding values for average prime cottonseed meal are 33.4 per cent and 75.5 per cent respectively. In palatability the two appear to be equal.

Artichoke silage, a succulent carbohydrate roughage, is similar in essential characteristics to corn silage. Though slightly lower in total digestible nutrients, it is, in general, probably a more economical feed than corn silage, since it originates as a by-product.

THE DIGESTIBILITY OF BROWN ALFALFA HAY, SESAME MEAL, AND ARTICHOKE SILAGE AS DETERMINED FOR RUMINANTS[1]

A. H. FOLGER[2]

INTRODUCTION

To aid the feeder of livestock in his search for low-priced feeds, and to assist industry in marketing its by-products, the University of California, through its Division of Animal Husbandry, has from time to time conducted tests to determine the nutritive values of new materials which, because of their chemical composition and volume, may prove important.

In arriving at feed value, there are two important considerations: the composition, as determined by chemical analysis, and the amount of each constituent actually digested by the animal. To ascertain the former is relatively simple, but to arrive at the coefficient of digestibility for a given feed is more tedious and complicated.

In 1926, the University published, in Agricultural Experiment Station Bulletin 409,[3] the digestible composition of dried orange pulp and dried raisin pulp; and in 1927, in Bulletin 439,[4] the results of trials with the dried pulps of the pineapple, lemon, and olive. The following pages contain the results of experiments to find the feeding values of brown or "tobacco" alfalfa hay, sesame meal, and artichoke silage. The methods used were essentially those formulated by the National Research Council for the determination of digestion coefficients.[5] They are described in detail in Bulletin 409 mentioned above.

Wether sheep were used. They are especially suited to digestion trials, being small and easily handled; the feces are easy to collect and process for analysis. The coefficients of digestibility determined by their use are applicable to cattle.[6]

[1] Received for publication January 9, 1934.

[2] Superintendent of Official Advanced Registry Tests.

[3] Mead, S. W., and H. R. Guilbert. The digestibility of certain fruit by-products as determined for ruminants. Part I. Dried orange pulp and raisin pulp. California Agr. Exp. Sta. Bul. 409:1–12. 1926.

[4] Mead, S. W., and H. R. Guilbert. The digestibility of certain fruit by-products as determined for ruminants. Part II. Dried pineapple pulp, dried lemon pulp, and dried olive pulp. California Agr. Exp. Sta. Bul. 439:1–11. 1927.

[5] Forbes, E. B., and H. S. Grindley. On the formulation of methods of experimentation in animal production. Natl. Research Council Bul. 6, part 2 (33):1–28. 1923.

[6] Armsby, H. P. The nutrition of farm animals. p. 603–605. The Macmillan Co. New York. 1930.

An alfalfa hay of known digestibility was fed with the sesame mea
In order to prepare the animals for each trial, a 10-day preliminar
feeding period was used. During the 15 days following this period
feces were collected for analysis.

RESULTS OF DIGESTION TRIAL WITH BROWN ALFALFA HAY

When hay with a high moisture content (30 to 50 per cent) is stacked
fermentation occurs, accompanied by marked rise in temperature. The
result is a product brown in color, with a mild tobacco odor and the mois-

TABLE 1

TOTAL FEED CONSUMED AND TOTAL FECES COLLECTED

Animal number	Hay fed	Feces collected
	grams	*grams*
1	15,921	17,723
2	13,163	13,320
3	13,958	14,566
4	11,165	11,995
5	11,657	14,510

TABLE 2

CHEMICAL ANALYSES OF FECES AND FEED

Animal number and feed analyzed	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
Feces:	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	31.57	4.31	10.46	1.34	11.47
2	31.71	4.54	10.32	1.60	10.93
3	32.70	4.70	10.81	1.31	11.62
4	32.15	4.06	11.23	1.39	11.75
5	29.99	3.82	10.45	1.28	10.87
Feed:					
Brown alfalfa hay	89.82	14.58	39.88	1.35	24.67

ture content of normal hay. Many feeders of livestock prefer this "tobacco" or "brown" hay to that cured in the usual manner (that is, with about 20 per cent moisture when stacked). They believe that the animals relish it more and that it is more nutritious.

In another experiment (the results of which have not been published), designed to study the causes of spontaneous combustion, some brown alfalfa hay of excellent quality was produced. The many inquiries received concerning the feeding value of this material led to a digestion trial, the results of which appear in tables 1, 2, 3, and 4.

As shown by table 4, the digestibility of all constituents in the brown alfalfa hay, except that of the crude fiber, was lower than that of average hay. These results might be expected. During fermentation there is

TABLE 3

COEFFICIENTS OF DIGESTIBILITY OF BROWN ALFALFA HAY

Animal number	Dry matter	Crude protein	Nitrogen-free extract	Ether extract*	Crude fiber
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
1	60.87	67.09	70.80	−10.50	48.24
2	64.27	68.50	73.81	−19.93	55.17
3	62.05	66.17	71.81	− 1.54	51.54
4	61.61	69.85	69.89	−11.03	49.81
5	58.50	67.15	67.53	−18.44	46.16
Average	61.46	67.75	70.77	Negative	50.18

* The digestibility of any constituent is determined by subtracting from the amount found in the feed that remaining in the feces; ordinarily less remains in the feces than was present in the feed and a positive figure for digestibility is obtained.

A negative coefficient occurs when the amount in the feces is greater than that present in the feed. This is most likely to occur where the constituent is present in a feed in small quantities as is the case with the ether extract in the brown alfalfa hay (table 2).

Negative coefficients are not infrequently found for ether extract for the reason that the feces contain unresorbed bile residues and other ether-soluble products of excretion. These increase the amount of ether extract present and minimize its apparent digestibility by concealing the amount actually remaining after the digestive process. In the present instance the total of the ether-soluble substances present in the feces is greater than was present in the feed, thus giving a negative result.

TABLE 4

COEFFICIENTS OF DIGESTIBILITY OF BROWN ALFALFA HAY AS COMPARED WITH AVERAGE ALFALFA HAY

Constituents	Brown alfalfa hay	Average alfalfa hay	
		Henry and Morrison* average of all analyses	Mead and Guilbert† determinations
	per cent	*per cent*	*per cent*
Dry matter	61.46	60	63.31
Crude protein	67.75	71	77.00
Nitrogen-free extract	70.77	72	73.45
Ether extract	.....	38	20.31
Crude fiber	50.18	43	48.49

* Henry, W. A., and F. B. Morrison. Feeds and feeding. 18th ed. 770 p. Appendix Table III. Henry-Morrison Co., Madison, Wis., 1923.

† Mead, S. W., and H. R. Guilbert. The digestibility of certain fruit by-products as determined for ruminants. California Agr. Exp. Sta. Bul. **409**:1-12. 1926.

a loss of crude protein and nitrogen-free extract, as a result of oxidation, while the value of the relatively indigestible crude fiber is enhanced by the bacterial action that tends to convert it into a more digestible form. A comparison of the total digestible nutrients of brown alfalfa hay with other feeds appears in table 11.

RESULTS OF DIGESTION TRIAL WITH SESAME MEAL

Sesame cake or meal, though used for feeding livestock in European countries for many years, is relatively new in California. The seed is grown extensively in China and other Oriental countries. Now that recent favorable exchange rates have stimulated its importation into California, where the oil is extracted, thousands of tons of residual meal are available for the feeding of livestock.

TABLE 5

TOTAL FEED CONSUMED AND FECES COLLECTED IN TRIAL WITH SESAME MEAL

Animal number	Alfalfa hay	Sesame meal	Feces
	grams	*grams*	*grams*
1	13,620	3,405	18,268
2	11,804	3,405	12,094
3	13,620	3,405	17,833
4	13,620	3,405	16,558
5	12,244	3,405	16,189

TABLE 6

CHEMICAL ANALYSES OF FECES AND FEED

Animal number and feeds analyzed	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
Feces:	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	29.81	4.00	9.88	1.25	9.86
2	33.51	4.98	10.36	1.65	10 34
3	29.56	4.39	9.49	1 19	9.48
4	33.00	4.50	11.22	1.31	10.30
5	32.34	4.44	10.81	1.28	10.23
Feeds:					
Brown alfalfa hay	89.82	14 58	39.88	1.35	24.67
Sesame meal	93.24	39.30	27.44	9.01	4.89

TABLE 7

COEFFICIENTS OF DIGESTIBILITY OF SESAME MEAL*

Animal number	Dry matter	Crude protein	Nitrogen-free extract	Crude fiber
	per cent	*per cent*	*per cent*	*per cent*
1	76.98	93.25	76.75	23.58
2†	.....	.....	.....	.....
3	82.47	89.35	88.80	90.04
4	76.40	92.18	71.09	81.09
5	68.59	89.31	65.45	9.15
Average	76.11	91.02	75.52	50.97

* As no coefficient of digestibility of ether extract for the brown alfalfa hay was available (table 3), it was impossible to compute, by the usual method, the similar coefficient for sesame meal. In other feeding qualities, this meal is comparable to such well-known feeds as cottonseed meal, coconut meal, and peanut meal. The digestibility of the fats in these feeds ranges from 90 to 100 per cent. To afford a basis of comparison with other feeds, a digestion coefficient of 90 per cent might conservatively be assumed. The figure for fat in table 11 was estimated in this manner.

† Number 2 did not eat as well as the other sheep and gave negative results.

Because new methods of extracting oil have somewhat changed the character of the meal, and because California stockmen, as indicated by the large number of inquiries received, are unfamiliar with its nutritional value, the Division of Animal Husbandry decided to determine digestion coefficients for its various nutrients.

The meal was fed with the brown alfalfa hay mentioned above, since this hay was of known digestibility. Probably the sesame meal, being

high in protein, would show a slightly higher value if fed with a low-protein hay. The data are given in tables 5, 6, and 7. A comparison of the total digestible nutrients of sesame meal with other common feeds will be found in table 11.

RESULTS OF DIGESTION TRIAL WITH ARTICHOKE SILAGE

When the globe artichoke (*Cynara scolymus*) is harvested for human consumption, the stalks and inferior heads are left in the field, consti-

TABLE 8

Total Feed Consumed and Feces Collected

Animal number	Artichoke silage (dry*)	Feces (dry)
	grams	*grams*
1	7,438	3,054
2	6,727	2,678
3	8,249	3,474
4	9,820	4,465
5	4,614	1,851

* Weigh-back deducted.

TABLE 9

Chemical Analyses of Feces and Feed

Animal number and feed analyzed	Dry matter*	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
Feces:	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	.....	14.8	32.4	2.9	20.6
2	.....	13.6	33.8	2.6	22.9
3	.....	14.5	32.9	2.9	21.4
4	.....	12.1	33.9	2.4	25.9
5	.....	15.2	32.9	3.1	19.6
Feed:					
Artichoke silage	30.20	6.82	45.81	1.68	27.15

* In this trial the feces were taken to the drying oven immediately on collection, and the dry weights recorded after removal from the oven.

tuting a serious impediment to the preparation of land for a subsequent crop. In Monterey county alone, this residue amounts to more than 140,000 tons annually.

Certain dairymen have used silos to preserve this material for cow feed. The animals eat it with relish, consuming as much as 30 to 40 pounds per day, and maintain their milk flow. It has also been used for wintering beef cattle and sheep.

Because of the interest in this feed, and the lack of information concerning it, a digestion trial was conducted. Artichoke silage obtained from a large dairy near Salinas was fed to the five sheep previously

used. The data on this trial appear in tables 8, 9, and 10; and table compares this with other common feeds.

The best known and most widely used silage is that made from cor for purposes of comparison between this and the artichoke silage t

TABLE 10

COEFFICIENTS OF DIGESTIBILITY OF ARTICHOKE SILAGE

Animal number	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
1	58.94	14.47	71.04	35.35	67.41
2	60.19	20.66	70.57	39.22	66.61
3	57.89	12.26	69.80	30.64	66.04
4	54.53	20.07	66.40	36.09	56.21
5	59.88	11.36	71.29	28.36	70.69
Average	58.29	15.76	69.82	33.93	65.39

TABLE 11

TOTAL DIGESTIBLE NUTRIENTS OF VARIOUS COMMON FEEDS COMPARED WITH THE FEEDS USED IN THESE TRIALS

Feed	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds			
		Crude protein	Carbo-hydrates	Fat	Total*
	pounds	*pounds*	*pounds*	*pounds*	*pounds*
Alfalfa hay†	91.4	10.6	39.0	0.9	51.6
Brown alfalfa hay	89.8	9.9	40.6	0.5‡	51.6
Prime cottonseed meal†	92.2	33.4	24.3	7.9	75.5
Sesame meal	93.2	35.8	23.2	8.1	77.2
Coconut meal†	90.0	19.9	44.2	3.0	70.8
Barley†	90.7	9.0	66.8	1.6	79.4
Corn silage†	26.3	1.1	15.0	0.7	17.7
Artichoke silage	30.2	0.3	15.0	0.2	15.8

* Total includes fat times the factor 2.25.

† Henry, W. A., and F. B. Morrison. Feeds and feeding. 18th ed. 770 p. Appendix Table III. Henry-Morrison Co., Madison, Wisconsin. 1923.

‡ For a comparison between the nutritive value of brown alfalfa hay and that of the other feeds in table 11, a coefficient of digestibility had to be assumed for the ether extract because, as shown in table 3 this value was negative, a result clearly not in keeping with the facts.

following digestion coefficients for corn silage are taken from Henry and Morrison:[7] dry matter 66 per cent, crude protein 51 per cent, nitrogen-free extract 71 per cent, ether extract 82 per cent, and crude fiber 6[illegible] per cent.

[7] Henry, W. A., and F. B. Morrison. Feeds and feeding. 18th ed. 770 p. Henry Morrison Co., Madison, Wis., 1923.

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SPARK ARRESTERS FOR MOTORIZED EQUIPMENT

J. P. FAIRBANK AND ROY BAINER

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UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

SPARK ARRESTERS FOR MOTORIZED EQUIPMENT[1]

J. P. FAIRBANK[2] AND ROY BAINER[3]

INTRODUCTION

THE INFLAMMABLE NATURE of vegetative ground cover during the dry summer season, throughout the major area of California, contributes to the fire hazards in fields and forests. In the rural districts, many fires have been attributed to ignition by the exhaust systems of motorized equipment. Fires started by internal-combustion engines may result from the emission of hot carbon particles in the exhaust stream; from contact between dry vegetation and hot exhaust pipes; or, under certain conditions, from actual contact between flames from the exhaust system and dry vegetation.

Carbon residue collects within the cylinder heads, in the mufflers, and on the piston heads of practically all internal-combustion engines. The amount and nature of this carbon depends somewhat upon the condition of the engine and upon the kind of fuel and lubricating oil used.

Under certain conditions, pieces of carbon residue break loose and are emitted with the exhaust gases. At the time of combustion, the gases within the engine cylinder range in temperature from 3000° to 4000° Fahrenheit; and they are exhausted at temperatures of 1200° to 1600° F. Since the temperature within the exhaust system is above the kindling point of the carbon, the carbon particles may well have temperatures approximating or even above exhaust temperatures, because they may be burning as they leave the engine. That they are hot enough to be incandescent is obvious when one watches a tractor, with no protective device on its exhaust system, working after dark. Sometimes a shower of sparks is thrown out in the exhaust stream when there is a sudden change in load or speed. Incandescent carbon particles may even be seen coming from the muffler tail-pipe of an automobile traveling the highway at night, and they often glow for several seconds after passing from the engine.

[1] Received for publication May 4, 1934.

[2] Specialist in Agricultural Extension.

[3] Assistant Professor of Agricultural Engineering and Assistant Agricultural Engineer in the Experiment Station.

The law, as passed by the 1931 California Legislature, regarding protective devices on internal-combustion engines, used under hazardous conditions, designates the following as a misdemeanor:

> Operating or causing to be operated any gas tractor, oil-burning engine, gas-propelled harvesting machine or autotruck in harvesting or moving grain or hay, or moving said tractor, engine, machine or autotruck in or near any grain or grass lands, unless he shall maintain attached to the exhaust on said gas tractor, oil-burning engine or gas-propelled harvesting machine an effective spark-arresting and burning carbon-arresting device.[4]

One question was raised immediately: What constitutes an effective spark-arresting device? The Divisions of Forestry and Agricultural Engineering, of the University of California, had made a few preliminary tests of spark arresters for tractors and harvesters in 1918.[5] On account of the development in recent years of new forms of arresters and of new types of tractors, the data on hand were not sufficient to give complete information on types of spark arresters fully complying with the law. In May, 1931, accordingly, the Stop Forest Fires Committee requested the Division of Agricultural Engineering to analyze the problem further. In addition, the Equipment Committee of the Rural Fire Institute of California, which had already selected this phase of fire prevention as an important problem, desired that additional study be made.

There was furthermore very little information available regarding the composition, size, and characteristics of the carbon particles emitted with the exhaust gases, or regarding the conditions under which fires might be started by carbon particles from internal-combustion engines or by contact with hot surfaces, such as exhaust pipes. The first step, accordingly, was to analyze some of this carbon material and to start fires in dry vegetation under different weather conditions, using carbon particles of various sizes and a section of exhaust pipe, both heated through the range of critical temperatures. The first part of this bulletin deals with this aspect of the problem, and the results of experiments with spark arresters are given in a later section.

CARBON COLLECTED FROM MOTORIZED EQUIPMENT

The amount of carbon ejected from an engine for a given length of time was not definitely determined. On one 60-hp. tractor of the U. S. Forest Service, however, 100 grams of carbon were caught during 100 hours of operation, or 1 gram per hour. The tractor had run a total of 3,900 hours.

[4] California Penal Code, No. 9. Sec. 384. Stats. 1931. Chap. 311, p. 749.

[5] Metcalf, Woodbridge. Fire protection for grain fields. California Agr. Exp. Sta. Bul. 295: 351–368. 1918. (Out of print.)

On a 40-hp. tractor of the U. S. Forest Service, 14.45 grams were caught in 144 hours of operation, or 0.1 gram per hour. This tractor had been run only 580 hours. These figures merely bear out the common observation that a worn engine produces more carbon than one in first-class condition.

Size of Carbon Particles.—Carbon was trapped by spark arresters on eight tractors, five used in general farm work, and three on road construction. The three latter were U. S. Forest Service tractors to which

TABLE 1

SCREEN ANALYSIS OF THE CARBON COLLECTED IN SPARK ARRESTERS ON EIGHT TRACTORS

Tyler screen	Size of opening, inches	Per cent retained
4-mesh	0.185	1.9
8-mesh	0.093	7.5
14-mesh	0.046	18.7
28-mesh	0.0232	27.5
Pan	....	44.4

had been attached large spark traps of the inertia type with the final openings covered by 16-mesh-to-the-inch wire cloth.

The carbon collected from each tractor was screened through a set of standard Tyler square-mesh screens (table 1).

As the data (table 1) show, over half the carbon ejected by the tractors was coarser than the 28-mesh screen. In most samples the carbon particles were hard and granular, but in one case they were soft and flaky. Fifty-three such flakes were not screened because of their large sizes, ranging from ¼ to ¾-inch maximum diameter. One large flake, not included among these, measured $^{9}/_{16}$ by $1^{5}/_{16}$ inches.

For the three tractors on which the time of operation was known, carbon was caught at rates ranging from 0.1 to 1.0 gram per hour. The rate of carbon accumulation should be considered in the design and use of spark arresters. A former tractor-service man reported a case of fires being started from one of his firm's tractors equipped with an arrester. Upon investigation, the chamber proved to be filled with carbon, which could be removed only by taking the arrester apart.

Kindling Temperature of Carbon.—A one-gram sample of each size of carbon caught from one tractor was analyzed to determine the quantity of ash and the kindling temperature (table 2).

The ash was not analyzed qualitatively except to determine that it

was mainly a form of iron, presumably worn from cylinders and rings.[6]

Since the kindling temperatures ranged from 887° to 1022° F,[7] it is evident that carbon can be ignited in the exhaust system of an internal-combustion engine.

Weight of Carbon Particles.—In weight, carbon particles from different samples varied widely. For example, 50 pieces from one sample passing through a 0.093-inch square mesh and caught on a 0.092-inch round-hole screen weighed 0.40 gram, or 0.008 gram each; while 100 pieces of another sample similarly screened weighed 0.11 gram, or 0.0011 gram each, a ratio of more than 7 to 1.

TABLE 2

KINDLING TEMPERATURE AND QUANTITY OF ASH FOR ONE-GRAM SAMPLES OF EACH SIZE OF CARBON

Tyler screen	Ash in grams	Kindling temperature of carbon retained, degrees Fahr.
4-mesh	0.810	.....
8-mesh	0.813	1022
14-mesh	0.799	1022
28-mesh	0.761	1004
Pan	0.605	887

SELECTION OF CARBON FOR FIELD TRIALS

The carbon selected for the field tests must correspond in general type to that ejected by engines, must not break into smaller particles when handled, and must not coke in the furnace, later to be discharged as a wad rather than as separate particles. Furthermore, it must be available in quantity. Trials were made with the following forms of carbon: (1) carbon electrodes from dry cell batteries, (2) coal coke, (3) oil coke, (4) carbon scraped from pistons and cylinder heads of internal-combustion engines, and (5) cinders from coal-burning locomotives. Experiments comparing these carbons under controlled laboratory conditions are given in a later section.

No one of the carbons used represented all types ejected from internal-combustion engines. The battery carbon, being very hard and heavy, did not burn readily nor coke. It was considered a useful indicator of the ease with which different forms of vegetation are ignited under various weather conditions; and it represented an inert or nonflaming type of material.

[6] The analysis of carbon samples was made by H. W. Allinger, of the Division of Chemistry, University of California.

[7] All temperatures in this bulletin are in degrees Fahrenheit.

No field tests were made with coal coke. One form of oil coke was unsuitable because it coked readily. "Cokettes," an oil-coke product used in orchard heating, were extensively used.

Carbon scraped from engines was probably the most representative of material ejected by exhausts. It had a tendency to burn after leaving the furnace and to break down into smaller particles. In some cases there was some coking effect in the furnace.

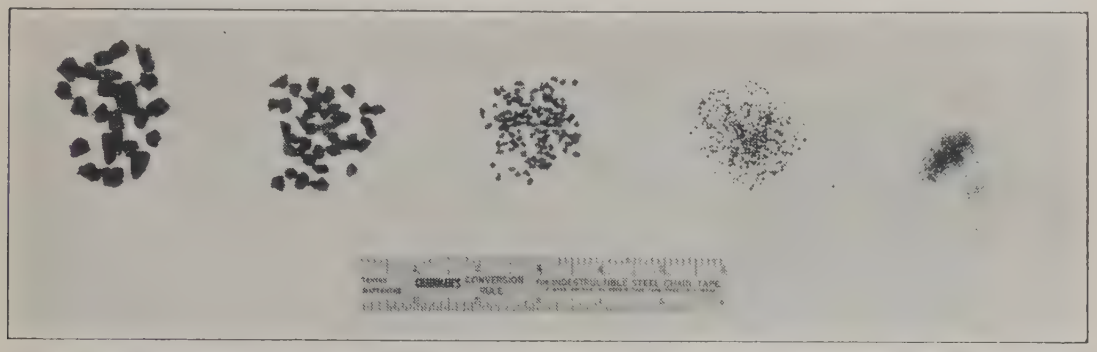


Fig. 1.—Comparative sizes of the five groups of carbon particles. Left to right, Nos. 1 to 5. Scale, in inches.

Cinders from coal-burning locomotives, collected on car roofs in Montana by members of the U. S. Forest Service, were used in a few field tests; but only small sizes were available. Being fairly inflammable, the coal cinders were not representative of the carbon ejected from internal-combustion engines.

TABLE 3

SCREENS USED IN SELECTING CARBON SAMPLES

Carbon size No.	Passing through Tyler screen	Size of opening, inches	Retained on	Size of opening, inches
1	2-mesh	0.371	4-mesh hardware cloth	0.221
2	4-mesh	0.185	No. 11 round hole	0.170
3	8-mesh	0.093	No. 43 round hole	0.092
4	14-mesh	0.046	Tyler 28-mesh	0.023
5	28-mesh	0.023	Pan	0.000

Carbon particles caught in spark arresters on tractors were used in a few tests, but the procurable supply was limited.

Five classifications of carbon sizes (fig. 1) were used. The basis for segregation was a set of Tyler square-mesh screens in which the diameter of each succeeding opening was one-half that of the one preceding. The range of sizes within each group was kept to a minimum by inserting other screens with openings slightly smaller than those of the corresponding square-mesh screen (table 3). All screening was done by means of a Ro-Tap machine.

EXPERIMENTAL PROCEDURE AND TEST AREAS

Equipment for Spark Tests.—Equipment was devised for heating ca bon to known temperatures and quickly ejecting it into vegetation, t determine the sizes and temperatures necessary to start fires.

A 2.5-kw. high-temperature, combustion tube furnace (fig. 2), rate at working temperatures up to 2500° F, was used for heating the carbo particles. Current was supplied by an engine-generator set mounted o a truck, and the temperature was controlled by voltage regulation.

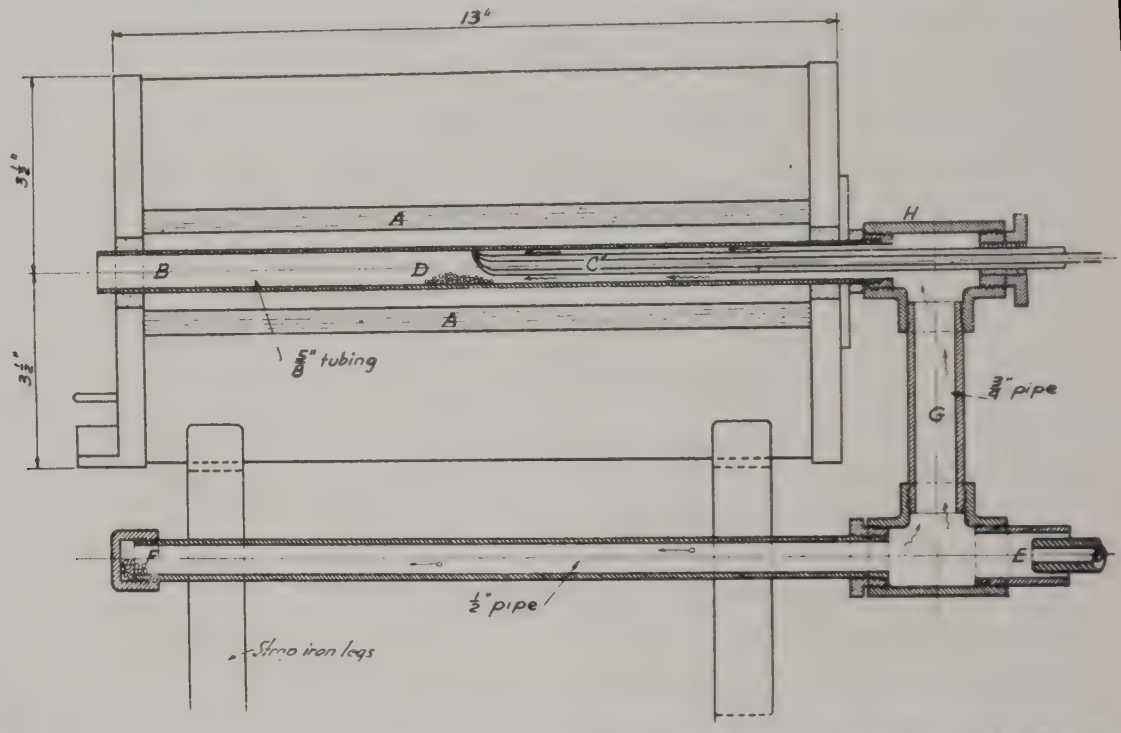


Fig. 2.—Portable electric tube furnace for heating carbon particles. *A*, Heating element; *B*, monel tube; *C*, thermocouple; *D*, carbon sample; *E*, rifle barrel; *F*, wads from cartridges; *G*, piping of the ejection system.

Within the tube the temperature was measured by a "platinum—platinum 10%—rhodium" thermocouple in a Fyrstan case, inserted in the combustion tube. This thermocouple was calibrated in millivolts, and the cold-junction was packed in a vacuum bottle containing ice. The sensitivity of the instrument was indicated by the fact that after the charge of carbon particles was placed in the furnace the millivolt meter needle would drop for a few seconds and then gradually return to the initial temperature.

Wind velocity was measured either with a standard Weather Bureau three-cup Tycos anemometer, mounted on a base so that the centers of the cups were 18 inches aboveground, or by a Biram-type 4-inch anemometer suspended 24 to 36 inches aboveground by a string from an arm on a staff and held into the wind by a light metal vane.

Air temperatures were read either from chemical thermometers suspended in the shade within 24 inches of the ground, or from the dry bulb of the psychrometer.

In measuring soil temperatures, a soil thermometer, standard grade, with pointed metal end, was inserted at such a depth that the bulb was at the surface of the soil.

Relative humidity was determined by sling or "egg-beater" types of psychrometers.



Fig. 3.—Dry oat grass (Davis).

Methods of Using the Equipment in the Field.—The truck carrying the 5-kw. engine-generator set was placed within 200 feet of the test plots, and the current was carried through 10-gauge weatherproof stranded conductors.

The furnace was placed on the ground in the plot, and the vegetation adjacent to it and to the instrument table, was cleared away. Fire guards around the plots, together with shovels, wet sacks, and knapsack pumps, were used to control the fires.

For each trial, two grams of carbon were used. The carbon particles burned but slightly when first put into the combustion tube, the flames ceasing within a few seconds, probably through deficiency of oxygen. Upon injection of the carbon, the millivolt meter needle dropped a few points. When it returned to the reading for the desired temperature, the carbon particles were ejected, either by shooting 0.22 or 0.32-caliber blank cartridges from guns, or by blowing into the pipe by mouth. The

carbon particles scattered widely, falling often within a few feet of th
furnace but occasionally 25 to 30 feet away. In general, the shots wer
made with the wind. The results were considered negative unless th
vegetation flamed. Smoke or a glow alone was not reported as a "fire.
The number of spot fires resulting from a shot was not reported, althoug
from one to eight spots may have ignited.

Field trials were conducted during the summers of 1931 and 1932 i
short, dry, immature oat and barley stubble at Davis, in grasslands i



Fig. 4.—Barley stubble (Davis).

Tehama County, in brush fields near Mt. Shasta, and in pine needles
near McCloud.

Dry Oats.—This field had been sown with oats that did not mature
because of a deficiency of moisture. The vegetative cover was mainly a
mat of grasslike nature with small blades and stems up to 10 inches in
length. There was a small percentage of barley, wild oats, and foxtail;
but all were small plants (fig. 3).

Barley Stubble.—The barley field had been harvested with a combine
leaving the stubble 8 to 12 inches high. Blades, chaff, and some heads lay
on the ground, clustered around the base of the stems (fig. 4).

Moisture samples of 200 to 300 grams each were taken. The average
moisture content of twelve samples was 7.1 per cent, the range being
from 2.2 to 14.5 per cent.

Range Grasses.—Field tests were made on two different plots of range
grasses in Tehama County: one on the Owens ranch about 12 miles west

of Red Bluff, and the other on the Mohr ranch about 8 miles north of the same city.

Range land on the Owens ranch consisted of rolling hills covered with a heavy stand of fine, dry grass somewhat matted and trampled (fig. 5). The larger plants still standing were from 10 to 18 inches high. The species of grass identified were as follows: soft cheat *(Bromus hordeaceus)*, smooth flowered soft cheat *(Bromus racemosus)*, Mediter-



Fig. 5.—Dry grass on range land (Owens ranch, Tehama County).

ranean barley *(Hordeum gussoneanum)*, and wild oat *(Avena fatua)*. Other plants than grasses identified were: lupine *(Lupinus)*, filaree *(Erodium)*, fiddleneck *(Amsinckia)*, and blow wives *(Achyrachaena mollis)*.

The average moisture content for ten samples was 7.18 per cent, the range being from 3.1 to 20.2 per cent. The large variation in the moisture content was undoubtedly due to the relative proportion of the material in the sample from plants which were still in contact with their root system and those which had been broken from their root system and were lying on the surface of the ground. Although the two types of vegetation were apparently of the same degree of dryness, it became apparent in drying the samples that those which were still in their natural position with the roots and stems intact contained a much greater moisture content than those which had been broken off and were lying loosely on the ground. It is probable that ignition took place in most cases in the latter. This material in general, did not run higher than 3 per cent moisture.

On the Mohr ranch the range land consisted of a small flat along a

dry creek where the vegetation was a sparse stand of grass 4 to 5 inches high (fig. 6). The species of grass were identified as follows: soft cheat *(Bromus hordeaceus)*, few-flowered fescue *(Festuca reflexa)*, hairy-leaved fescue *(Festuca confusa)*, and red brome *(Bromus rubens)*. Other plants than grasses identified were as follows: Turkey mullein *(Eremocarpus setigerus)*, filaree *(Erodium)*, knotweed *(Polygonum californicum)*, and clover *(Trifolium microcephalum)*.

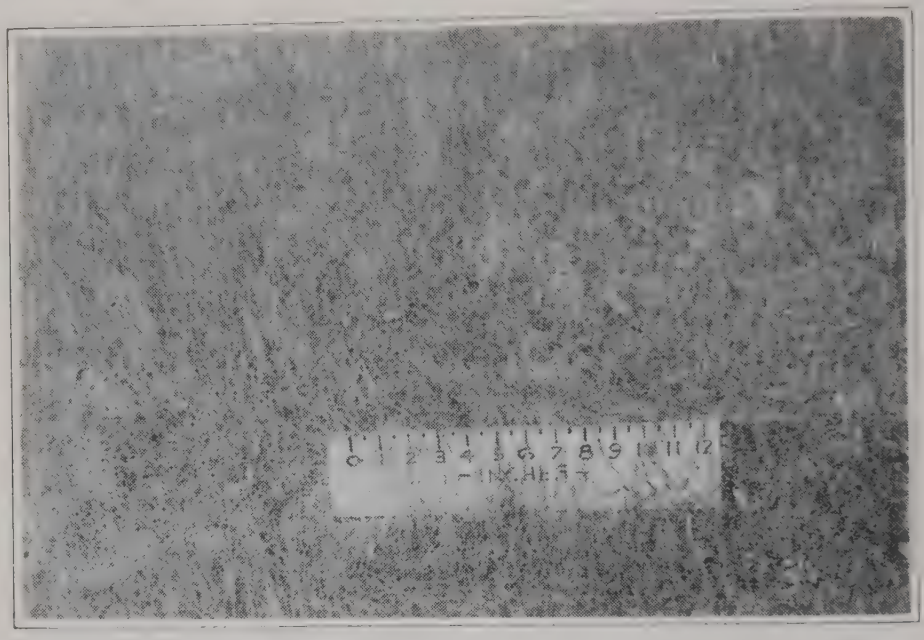


Fig. 6.—Dry vegetation (Mohr ranch, Tehama County).

The average moisture content of nine samples was 9.4 per cent, the range being from 2.9 to 20.7 per cent.

Pine Needles.—The test plot was located in a stand of second-growth ponderosa pine about fifty years old, near McCloud. The crown density, as expressed by foresters, was about 0.5, and the depth of needles on the ground averaged 2½ inches. There was no undergrowth or other ground cover (fig. 7).

The average moisture content of five samples was 7.1 per cent, the range being from 5.1 to 9.3 per cent.

Brush Field Litter.—This test plot was in a brush field near the town of Mt. Shasta. The vegetation consisted of manzanita, whitethorn ceanothus, and bracken (fig. 8). The litter on the ground, about an inch deep, was composed of twigs, branches, and leaves, typical of brush fields.

The average moisture content of three samples of the ground cover was 14.1 per cent, the range being from 11.5 to 17.7 per cent.

Weather Data.—The field tests were all made in August, when many range and forest fires are expected, but few grain fires, because the grain has been harvested.

During the 1931 field tests, the temperature readings ranged from 83° to 108°; the relative humidity, from 13 to 40 per cent; and the wind velocity, from 0 to 6 miles per hour (table 4).



Fig. 7.—Pine needles (Shasta County).

Table 4 shows that, with the exception of one day, the 1932 tests were not made during a period of high fire hazard. The average temperatures were lower and the relative humidities higher than for the 1931 tests.



Fig. 8.—Brush field (Shasta County).

In general, at an air temperature of 80° the relative humidity was 30 per cent or less; at 100°, 20 per cent or less. At 110°, with a relative humidity of 10–12 per cent, the fire hazard was extremely high.

TABLE 4

CONDENSED WEATHER DATA, 1931 AND 1932

Place	Date	Time	Air temperature, degrees Fahr.		Relative humidity, per cent		Wind velocity, miles per hour	
			Range	Average	Range	Average	Range	Average
Davis	Aug. 21, 1931	3:05 p.m. to 5:34 p.m.	92 to 98	95	12 to 23	17	1.0 to 3.2	2.1
	Aug. 22, 1931	9:30 a.m. to 3:01 p.m.	83 to 101	94	19 to 30	21	0.0 to 6.0	5.0
	Aug. 25, 1931	12:45 p.m. to 4:46 p.m.	103 to 108	105	13 to 18	14	0.0 to 2.0	0.4
	Aug. 26, 1931	4:10 p.m. to 8:05 p.m.	75 to 101	87	14 to 40	28	.....	
Davis	Aug. 10, 1932	10:00 a.m. to 5:00 p.m.	73 to 84	80	30 to 43	35	1.0 to 5.0	3.9
	Aug. 11, 1932	10:00 a.m. to 4:30 p.m.	72 to 89	81	24 to 50	37	0.8 to 4.9	2.2
	Aug. 25, 1932	1:30 p.m. to 2:20 p.m.	100 to 103	101	19 to 22	20	4.5 to 6.0	5.3
Owens ranch	Aug. 16, 1932	10:00 a.m. to 5:30 p.m.	78 to 86	83	15 to 27	19	2.6 to 5.3	4.1
Mohr ranch	Aug. 17, 1932	9:30 a.m. to 4:45 p.m.	77 to 92	87	10 to 23	17	0.3 to 4.6	2.6
Mount Shasta	Aug. 18, 1932	1:00 p.m. to 5:45 p.m.	78 to 85	83	14 to 20	17	1.9 to 4.5	3.2
McCloud	Aug. 19, 1932	11:15 a.m. to 4:00 p.m.	78 to 84	81	16 to 29	20	0.3 to 1.9	1.3

Relation of Moisture Content of Vegetation to Time of Day.—Averages for the samples of vegetation consistently showed the lowest moisture content at between 1 and 3 p.m., the time of highest air temperature and lowest humidity. The average moisture content was 15 per cent above the mean at 11:00 a.m. and 5:30 p.m., and 30 per cent below the mean at 3:00 p.m., showing the rapid response of grass and pine needles to weather conditions.

Relation of Soil Temperatures to Air Temperatures.—Samples of vegetation brought into the laboratory and oven-dried required higher temperatures of sparks for ignition than in the field with equivalent air

TABLE 5

SOIL TEMPERATURES IN RELATION TO AIR TEMPERATURES

	Average air temperature, degrees Fahr.	Average soil temperature, degrees Fahr.	Difference, degrees Fahr.
Davis, barley stubble	83	101	18
Owens ranch, tall grass	83	101	18
Mohr ranch, short grass	87	110	23
Mt. Shasta, brush field	83	102	19
McCloud, pine needles	81	97	16

temperatures. A question was thus raised concerning the possible effect of higher temperatures on the vegetation lying on the ground in the fields exposed to sunshine. The temperature of the soil surface, measured with soil thermometers, ranged from 16° to 23° higher than the air temperature, a fact that may have affected the tendency to ignite. Evidently, therefore, ignition tests should be made in the field under natural conditions (table 5).

Effect of Humidity on Inflammability of Vegetation.—The effect of humidity cannot be segregated from that of temperature; but when the spark tests are grouped according to humidity, irrespective of temperature, the data show that at a humidity of 10 to 29 per cent, fires were started with No. 2 carbon at temperatures of 1300°; for 30 to 39 per cent, 1700°; and for 40 to 50 per cent, 1900°.

RESULTS OF SPARK TESTS IN THE FIELD

A summation of all the spark tests (table 6) includes the total number of shots made for each carbon size, the number of shots resulting in fires, and the number of carbon particles used for each shot in which a fire occurred. In this last case the number of pieces per gram, for the different sizes of cokettes, was taken as an average for all types of carbon used.

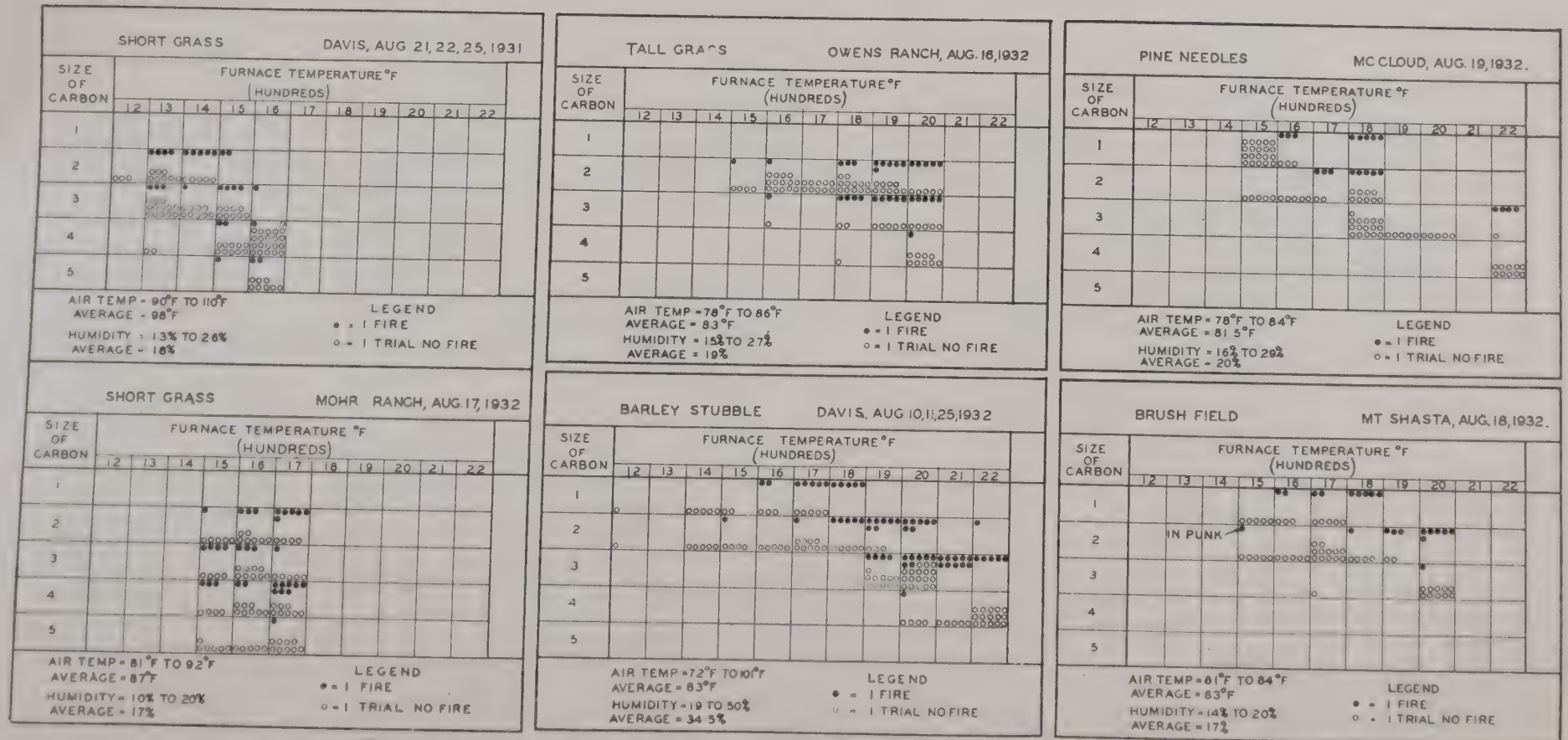


Fig. 9.—Results of certain aspects of the field trials, not shown in the tables.

The approximate ratio of the number, per fire, of carbon particles, sizes 2, 3, 4, and 5, was 2.5, 25, 100, and 5,000 to 1, respectively. Sizes 1 to 4, inclusive, appear, then, relatively hazardous; but the danger from size 5 may be small. In all four fires occurring with size 5, engine piston scrapings or railroad coal cinders were used.

TABLE 6

SUMMATION OF SPARK TESTS IN FIELD

Carbon size No.	Number of shots	Number of fires	Number of pieces for each fire
1	100	30	40
2	245	77	102
3	192	61	983
4	148	19	4,050
5	27	4	210,000

All spark tests in the field are summarized in the graphs shown in figure 9. One field cannot be directly compared with another because of the numerous variables, including temperature, humidity, moisture content, and characteristics of the vegetation.

Spark Tests in Dry Grass.—In dry oats at Davis, 1931, fires were started with the carbon heated to temperatures of 1300° for sizes 2 and

TABLE 7

COMPARISON OF TEMPERATURE AND HUMIDITIES, 1931 AND 1932

Year	Place	Temperature, degrees Fahr.		Humidity, per cent	
		Range	Average	Range	Average
1931	Davis	90–110	98	13–26	18
1932	Mohr ranch	81– 92	87	10–20	17
1932	Owens ranch	78– 86	83	15–27	19

3, and 1500° for sizes 4 and 5. In 1932, the range grasses on the Mohr ranch were ignited at temperatures of 1500° for sizes 2 to 4; and in one case ignition occurred with size 5 at a temperature of 1700°. On the Owens ranch a fire was started with size 2 at 1500°, and with size 3 at 1600°. Fires were not started consistently until the temperatures reached 1800°.

The plots on the Mohr and Owens ranches were most nearly comparable to the 1931 tests at Davis, as to the nature of the vegetation; but the temperatures required to start fires were about 200 degrees higher in 1932 than in 1931.

The air temperatures during the 1931 tests were higher than dur ing the 1932 tests, but the average humidities were nearly the sam (table 7).

Spark Tests in Brush Cover.—The vegetation on the ground in th brush fields was ignited at 1600° with size 1 carbon, at 1800° with size 2 and at 2000° with size 3, except that in one case dry rotten wood (punk was ignited at 1500° with size 2, the same temperature and size tha ignited grass on the Mohr and the Owens ranches.

Spark Tests in Pine Needle Litter.—Pine needles caught fire with size 1 carbon at 1600°, and at 1700° with size 2; but fires were not started with size 3 below 2200°.

These tests indicated that brush cover and pine needles (except in the case of punk) are about equally susceptible to carbon sparks but are less easily ignited than dry grass.

During tests in the brush field and the pine forest, several specimens of punk were placed near the carbon particles being ejected from the furnace. The punk was found not only to be readily ignited but to cause hang-over fires; that is, fires that did not blaze immediately, but continued to smoulder and finally burst into flame. In one case the elapsed time was 40 minutes.

With the other types of vegetation, the fires started within 1 to 3 seconds, except once when a brushfield fire was not observed until after 10 seconds.

Spark Tests in Barley Stubble.—Trials were made in barley stubble in 1932. The minimum temperature for ignition was 1500° with size 2 carbon. Fires were consistently started with sizes 1 and 2 at temperatures of 1700° and 1800°, and with size 3 at 1900°. With size 4 one fire started at 2000°, and one at 2400°.

Distance Fires Started by Sparks from Furnace.—The fires started at distances from 1 to 30 feet from the furnace, usually within 15 feet. No attempt was made to determine the maximum distance at which the sparks would start fires.

TESTS ON IGNITING VEGETATION BY MEANS OF HOT SURFACES

A possible cause of field fires is vegetation in contact with hot surfaces, as when the exhaust pipe of a truck passes through grass or grain. Vegetation sometimes lodges on an exhaust manifold when a tractor passes under trees or when straw falls or is blown against the engine of a combine.

A surface heater, devised to simulate a hot exhaust pipe, was used to determine at what temperatures vegetation might be ignited by hot sur-

faces. A 600-watt heating unit, like that used in a radiant heater, was mounted in a 5-inch length of seamless steel tubing, outside diameter 1¾ inches (fig. 10). To the ends of the tubing and perpendicular to its axis was attached a handle, which supported the wires conducting the electric current to the heating element, and also the thermocouple leads. A copper-constantan thermocouple was brazed to the surface of the tubing. The lead wires ran to the cold-junction, and were connected at will with the millivolt meter by means of a commutating switch.



Fig. 10.—Surface heater in use.

These tests were made in the same vegetation and during the same periods as the spark ignition experiments. The record includes the hour, air temperature, heater temperature, length of contact with vegetation (in seconds), relative humidity of the air, and result as to fire. In 35 out of 51 trials made, ignition occurred during periods of contact ranging from 0 to 120 seconds, with heater surface temperatures from 900° to 1282°. The air temperature range was from 65° to 100°; the relative humidity from 19 per cent to 44 per cent (table 8).

No fires started with temperatures of less than 800° for contacts of 2 minutes' duration. For temperatures above 800°, fires started 35 times out of 48 trials.

In general, the results are consistent; but a few are out of line with the trend, probably because of the element of chance involved in the variable vegetation. Fires started in one second or less after contact in 17 cases, showing the possibility of hot exhaust pipes' starting fires while the machine is moving.

Practically instantaneous ignition occurred in 5 out of 18 trials in the 1100° to 1199° temperature range, and in 14 out of 17 trials in the 1200° to 1299° range.

In the temperatures below 1100°, the shortest period of contact that started fire was 20 seconds—at a temperature of 1085°.

The lowest temperature at which fire started was 838°, with 2 minutes' contact; but with an increase of only 6° (844°), a fire started in 1 minute 10 seconds.

TABLE 8

SUMMARY OF FIRES STARTED BY CONTACT OF DRY OATS WITH A HOT SURFACE

Heater temperature, degrees Fahr.	Number of times fire resulted	Number of times no fire resulted
Less than 800	0	3
800 to 899	2	0
900 to 999	2	3
1000 to 1099	4	2
1100 to 1199	13	5
1200 to 1299	14	3
Total	35	16

No fires were started by contact with barley stubble at Davis, although the temperatures were as high as 1400°. Air temperature varied from 73° to 83°; relative humidity, from 20 to 50 per cent.

On the Owens ranch, fire started in grass on contact when the temperature of the pipe was 1390° (air temperature 86°, relative humidity 16 per cent). On the Mohr ranch, the pipe was covered with dry grass; and the temperature increased from 800° to 1225° before fire started (air temperature 90°, relative humidity 17 per cent).

Pine needles were not ignited by contact at 1400° but did start at 1340° when the pipe was covered with pine needles and the temperature was increased until ignition took place. Punk wood was ignited by contact at 1400° (air temperature 83°, relative humidity 16 per cent). The surface heater started fires when touched to vegetation at temperatures from 100° to 160° lower than the minimum temperatures at which carbon sparks started fires under the same conditions of vegetation and weather.

CONTROL EXPERIMENTS TO DETERMINE BURNING EFFECT OF CARBONS USED

Since the field trials indicated that the different sizes and kinds of carbon, when heated to the same temperature, varied in their tendency to start fires, it was desired to check these differences more accurately by means of laboratory tests. It was also desired to check the assumption

that the furnace temperatures used were within the range of temperatures imparted to carbon ejected by engines.

In these comparisons, the heated carbon particles were ejected upon sheets of cotton (outing) flannel, and the resulting scorched or burned spots were observed.

In comparing the different types of carbon, 12 × 12 inch sheets of the cotton flannel were placed in a pan 28 inches from the high-tempera-

TABLE 9

Temperatures Producing Moderate Scorch

Type of carbon	Carbon size	Temperatures producing moderate scorch, degrees Fahr.
Battery	2	1100
Cokette	2	1100
Engine scrapings	2	1100
Battery and cokette	3	1300
Engine scrapings	3	1100
Battery and cokette	4	1700
Engine scrapings	4	1100

ture combustion furnace used in the field trials. A one-gram sample of the carbon under test was heated in the furnace to the desired temperature and ejected upon the cloth by blowing through the furnace tube. Two trials were made with each size and type of carbon at intervals of 100°. The cloths could be readily segregated as to comparative degrees of scorching.

For comparing the effects of the different carbon temperatures, the results were classified into four degrees of scorch:

1. None; no scorched spots visible.
2. Slight; faintly visible scorched spots.
3. Moderate; distinct brown or black scorched spots, but no holes burned through the cloth.
4. Heavy; very distinct black spots, and some holes burned through the cloth.

Battery carbon and cokettes gave practically the same results for the three sizes used, namely 2, 3, and 4. For size 2, engine scrapings, battery carbon, and cokettes gave approximately equal scorch at temperatures from 900° (slight scorch) to 1200° (heavy scorch). For size 3, engine scrapings caused equivalent scorch at temperatures of 100° to 200° lower than did battery carbon and cokettes. For size 4, engine scrapings caused equivalent scorch at temperatures of 300° to 600° lower than did

battery carbon and cokettes (table 9). Some size 4 carbon removed fro tractor spark arresters caused equivalent scorch at temperatures 300° to 500° lower than battery carbon and cokettes.

Table 9 shows that moderate scorch was caused by scrapings of siz 2, 3, and 4 at 1100°, irrespective of size; while for battery carbon an cokettes the same effect was produced by size 2 at 1100°, by size 3 a 1300°, and size 4 at 1700°.

Heavy scorch was caused by size 2 of battery carbon, cokette, an engine scrapings at 1200°; by size 3 of engine scrapings at 1300°; an of battery carbon and cokette at 1400°. With size 4, it was not obtaine by battery carbon and cokettes until a temperature of 1800° wa reached, but occurred at 1500° for engine scrapings.

These tests were intended to correlate the probability of fires' being started by the different sizes and temperatures of carbon discharge from an engine exhaust, with the results of field trials where battery carbon or cokettes were mainly used. An approximate correlation be tween cokettes and engine scrapings follows:

Cokettes size 2 at 1100°=engine scrapings size 2 at 1100°
Cokettes size 3 at 1350°=engine scrapings size 3 at 1200°
Cokettes size 4 at 1750°=engine scrapings size 4 at 1333°

Carbon particles designated as size 5 are those that pass through a 28-mesh screen with openings 0.023 inch in diameter; for cokettes this means about 15,000 pieces per gram. Although this extremely small size would not appear to be a fire hazard, three fires were started in grass with such piston scrapings and railroad carbon within a few feet of the furnace. In special trials of the scorching effect of size 5, made with cotton flannel sheets, the cokettes caused no scorch up to 1500° and moderate scorch at 1600°. The engine scrapings, however, caused slight scorch at 1200° and moderate scorch at 1500°. They glowed brightly when ejected at 1200°, appearing to burn as they traveled through the air. When the furnace was raised to a height of 5 feet, they ceased to glow slightly less than 9 feet from the furnace, while falling through the air. At 1500° they caused moderate scorch on the cloth 7 feet from the furnace.

These tests and the field trials indicated that fires may be started by size 5 carbon striking dry grass within a few feet of the exhaust; but if the exhaust pipe is vertical the carbon particles will be cooled below the danger point before reaching the ground.

Of the other sizes of carbon, some particles were still glowing when they fell 20 to 60 feet from the furnace. During field tests at night carbon of miscellaneous sizes that had been caught in a spark arreste

glowed from 9 to 30 seconds after leaving the furnace. Scrapings of size 4 glowed from 10 to 15 seconds. According to these results, cooling by passing a short distance through the air does not always prevent fires from particles of size 4 and larger.

Comparison of Carbon Used in the Field Tests with Carbon Ejected by Engines.—A tractor, with the arrester removed, was run under full load on a Sprague electric belt dynamometer. Battery carbon and cokettes of size 3 were fed into the carburetor air intake. The particles were discharged from the exhaust to a large sheet of cotton flannel on the ground, causing scorched spots equivalent to those obtained from size 3 battery carbons and cokettes from the furnace at 1300°. Some of the spots were 8 feet from the exhaust pipe.

Most of the carbon particles were ejected almost instantaneously, some within ten seconds after being fed into the carburetor, whereas with the furnace a half minute or more was required to bring the size 3 particles up to the furnace temperature. According to this test, nonflaming particles may have a temperature of at least 1300°, or higher in case they are not discharged soon after becoming dislodged from the piston head or cylinder head.

A Model A Ford engine, run for 24,000 miles without removal of the carbon, was treated with a carbon remover one evening. The next morning the engine was run slowly to warm up, then "raced." Particles of carbon ejected from the engine ignited cotton batting held in a frame 18 inches back of the tail pipe, even after passing through the regular muffler and exhaust-pipe system.

The same effect was obtained by discharging size 4 engine scrapings from the electric furnace at 1400° upon the same sample of cotton batting held 3 feet away.

These trials indicate that the temperatures used in the field trials with the furnace were within the range of engine exhaust systems—a conclusion further substantiated by a review of literature on internal-combustion engine temperatures. Ricardo[8] gives 1640° as the temperature of the exhaust gas at the completion of the cycle. General Motors Research Laboratories[9] report the maximum temperature of exhaust gases of automobile engines as 1000° to 1600°.

[8] Ricardo, Harry R. The high speed internal-combustion engine. 435 p. 292 fig. Blackie and Son, London. 1931.

[9] Correspondence with Ernest E. Wilson. Dynamics Section General Motors Research Laboratory, June 4, 1931.

EXPERIMENTAL PROCEDURE IN TESTING SPARK ARRESTERS

Many spark arresters in common use, and some experimental arresters were tested first as to their efficiency in arresting carbon particles, and second as to their restrictive effect upon the engine exhaust system. Tests were made on these arresters while attached to the exhaust system of a 28-hp. 4-cylinder engine having a 4⅛-inch bore and a 5¼-inch stroke and operating at 1,150 r.p.m. Being belted to a Sprague dynamometer, the engine could be run under load as well as idling.

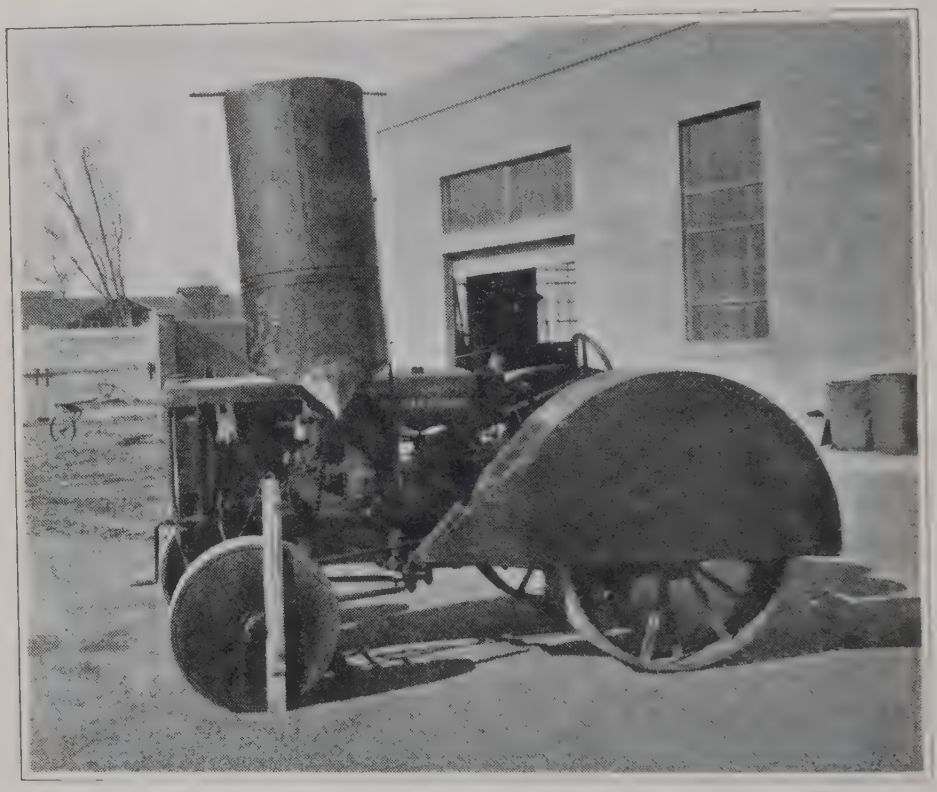


Fig. 11.—Tractor with spark trap in which the arrester efficiency tests were made.

Two sets of tests were run on each arrester. In the first, which were of a visible nature, 2-gram samples of carbon particles, sizes 2, 3, 4, and 5 (table 3), were heated to incandescence in a small combustion-tube furnace (fig. 2) and then introduced into the exhaust system through the throat of a Venturi tube built into the exhaust line, between the manifold and arrester. Because of the low pressure in the throat of the Venturi tube, carbon particles could be introduced against the back pressure of the exhaust system. These tests were run at night so that the path taken by any carbon particles passing through the arrester, together with characteristics peculiar to any one arrester, could be observed.

The actual efficiencies of the arresters were determined in a second series of tests, more positive in nature. The arrester, while attached to

the same engine, was entirely enclosed in a 24 × 36 inch trap (fig. 11) made of 20-gauge iron, with a hoppered bottom having, at the lowest point, an outlet for carbon removal. The top of the trap, telescoping the bottom part, was easily removed, making the arrester readily accessible. The exhaust gases escaped through a screened opening, 8 inches in diameter, located in the top.

Three tests, in which 100-gram samples of carbon sizes 2, 3, and 4 were used, were run on each arrester while the engine was working under full load. Idling and variable speed tests were run only on the arresters that showed high efficiencies while tested under load.

At this point it was thought unnecessary to include carbon particles of size 5 in the test. Field trials had shown that carbon of this size was not apt to start fires but, instead, lost its heat rapidly. When heated to an initial temperature of 1800°, it ceased to glow within a distance of 9 feet from the furnace. In practice, therefore, the exhaust pipe could be turned up to discharge into the air, thus providing the necessary distance for cooling the smaller particles before they reached the ground.

All carbon samples used in this test were oven-dried because the moisture content of the sample affected the final results. In other words, the temperature of the exhaust gas was sufficiently high to drive off this moisture, which, in some cases, amounted to as much as 6 per cent by weight.

After each test, the carbon was removed from the arrester and trap and was screened to determine how much it had been broken up. For example, the total weight of carbon passing through one arrester and caught in the trap was 23.99 grams. Of this amount, as shown by the screen analysis, 17.43 grams was of the same size as the original sample, while the difference of 6.56 grams was broken up finer than the original sample. In computing the efficiency of this arrester for carbon particles of this particle size, the 6.56 grams was not charged against the arrester.

A comparison of the screen analyses showed little variation in the extent to which the different arresters broke up the carbon. Probably the small variation noted resulted from differences in the carbon samples. As nearly as possible, however, the same carbon material was used throughout all tests.

Though carbon samples of 100 grams each were employed for each test, the efficiencies were based upon the total carbon caught in both the arrester and the trap. Occasionally some carbon fed into the line was drawn back into the exhaust manifold at the completion of a run, with those arresters that retained the carbon in the exhaust line until it became fine enough to pass through the arrester. Since occasionally some

of the carbon drawn back into the manifold would reappear in the ne run, the total caught amounted to 100 grams plus or minus a sma amount.

Only the carbon that retained its original size after passing throug the arrester was considered in determining the efficiency for any or size. For example, the average of the total carbon caught in the test o one arrester was 100.40 grams. The average screen analysis after th tests showed the weight of original carbon in the trap to be 17.43 gram The efficiency of this arrester for carbon size 2 was then found in th following manner:

$$\text{Efficiency}=\frac{100.40-17.43}{100.40}\times 100=82.64 \text{ per cent.}$$

The efficiency of the arrester for each size of carbon was determined i the same manner.

Sometimes the arrester did not retain the carbon particles yet brok them up somewhat; so it was credited with the amount that it reduce their size. For example, the average weight of carbon size 4 for the on arrester was zero; yet the efficiency, for this size, was rated at 15.36 pe cent because this amount of carbon had been reduced in size. In thi instance the efficiency $=\frac{98.26-83.17}{98.26}\times 100=15.36$ per cent. Another in teresting case was that of an experimental harvester arrester whic received an efficiency rating of 100 per cent for carbon particle size although an average of 3.71 grams passed through it. All the carbon o this size passing the arrester, however, became smaller than the original

When practicable, the restrictive effect of the different arresters wa measured by a U-tube manometer containing water and having one sid attached to the exhaust pipe just ahead of the arrester, while the othe side was open to the air. In a few instances the water had to be replace with mercury to measure higher pressures.

TESTS OF INERTIA-TYPE ARRESTERS

The Yuba Spark Arrester.—The original Yuba arrester used in thi experiment (fig. 12) consisted of an inner cylinder cast integral wit the base, an outer cylinder concentric with the inner and made of 1 gauge steel, a top cast in the shape of a semicircle of revolution, and cast-iron spiral held by a pin in the central cylinder. The spiral wa located with its top 1½ inches below the top of the inner cylinder. Thre lips cast as a part of the top and bottom provided a place for attachin three bolts, which held the arrester together.

As the gas and carbon particles passed through the spiral, they were set into a swirling motion. Upon leaving the inner cylinder, the gas passed through the opening in the top directly to the outside, while the

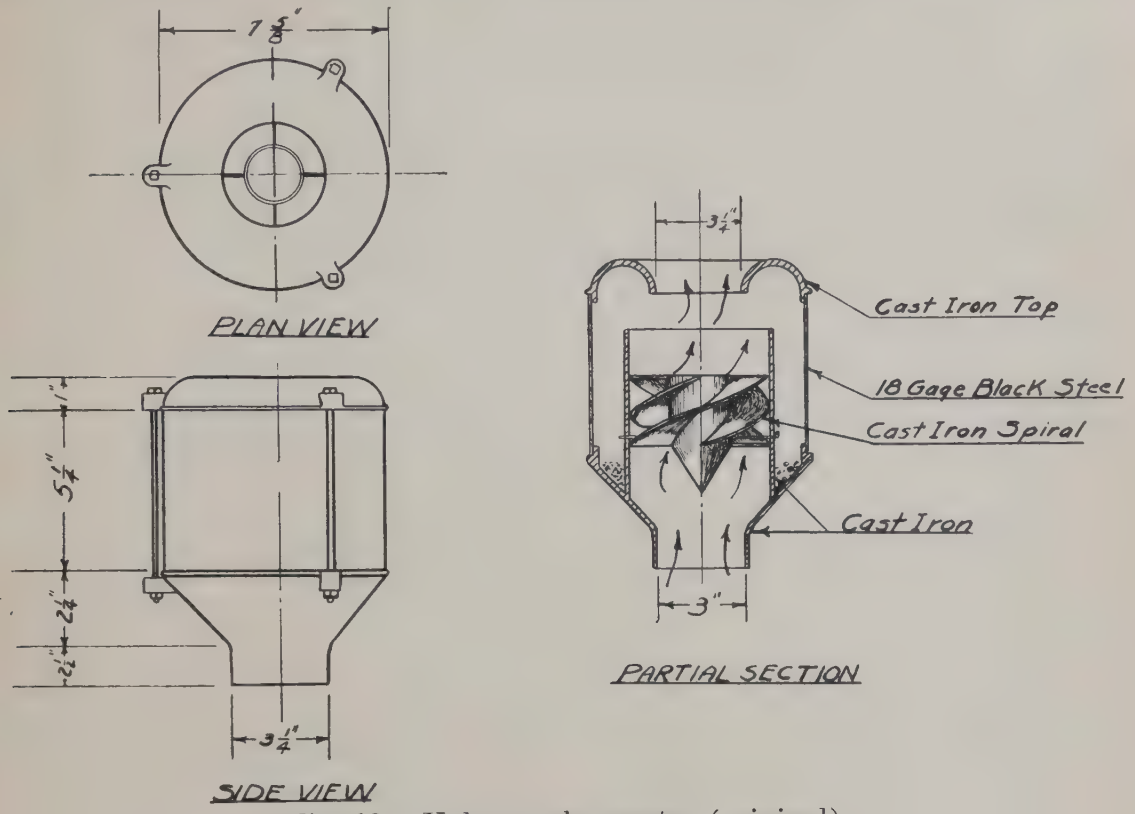


Fig. 12.—Yuba spark arrester (original).

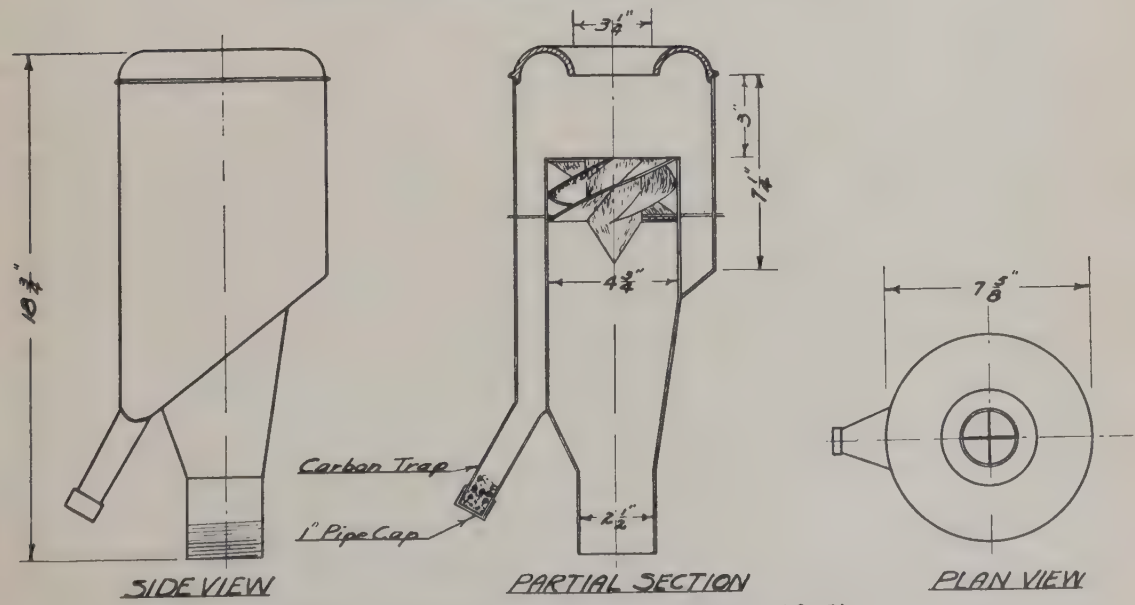


Fig. 13.—Yuba spark arrester (modified).

carbon particles were thrown by centrifugal force into the chamber between the inner and outer cylinders, where they were retained.

Tests conducted after dark, with glowing carbon particles, showed pieces of carbon occasionally leaving the spiral and hitting the inside wall of the inner cylinder at such an angle that they would bounce back

into the exhaust stream and be carried out through the opening in th top. By a slight modification, in which the spiral was raised until its to was flush with the top of the inner cylinder, and by means of a new outs shell 2 inches longer than the original (fig. 12), this fault was nearl eliminated. The new shell was also made with a hoppered bottom t facilitate cleaning.

The modified arrester (fig. 13) offered very little restriction on th exhaust system, the gas passing almost directly through it. When at tached to the test engine, it caused a back pressure of 1.75 inches o water (table 10).

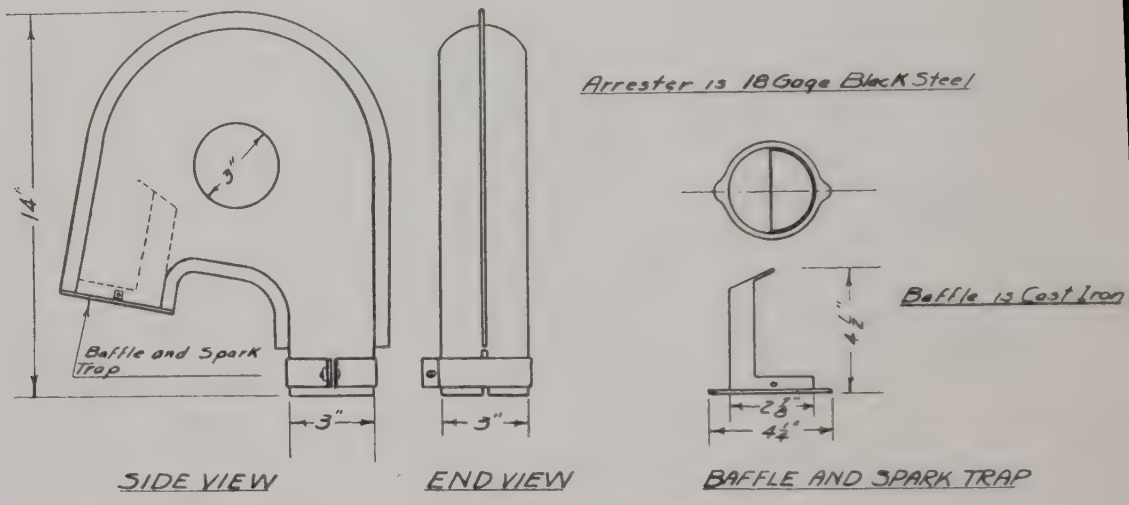


Fig. 14.—Cletrac cyclone spark arrester.

The efficiencies for this arrester, in its original form, were 98.0, 96.8, and 69.3 per cent, respectively, for carbon particle sizes 2, 3, and 4. In the modified design these efficiencies were raised to 99.6, 99.3, and 97.6 per cent for the three respective sizes of carbon particles (table 11). The efficiency of the rebuilt arrester was from 1.3 per cent to 3.2 per cent lower when tested in a horizontal position than when tested in a vertical position (table 11). The factory now builds this improved model.

The Cletrac Cyclone Arrester.—The spark arrester known as the cyclone, goose-neck, or question mark, consists of an outer shell, stamped in two parts from 18-gauge steel, then clinched together and held by a seam completely encircling it (fig. 14). Three-inch openings through the center of each side permit the exhaust gas to pass outside. A spark trap located in the path of the gas collects and retains the carbon particles.

Upon entering the arrester, the gas and carbon particles are immediately directed through a circular course. The centrifugal force thus set up throws the particles to the outer edge of the exhaust stream, where

they are separated from the gas by the baffle and fall into the trap. The trap may be removed for cleaning by taking out one bolt.

After a complete series of tests with the arrester in its original form, the outlets were covered with iron-wire screen of 16 meshes per inch, and another complete series was run.

The efficiencies for the Cletrac Cyclone were 98.7, 98.2, and 79.0 per cent, respectively, for carbon sizes 2, 3, and 4 without screens; 100, 99.9, and 80.8 per cent, respectively, when the outlets were screened (table 11).

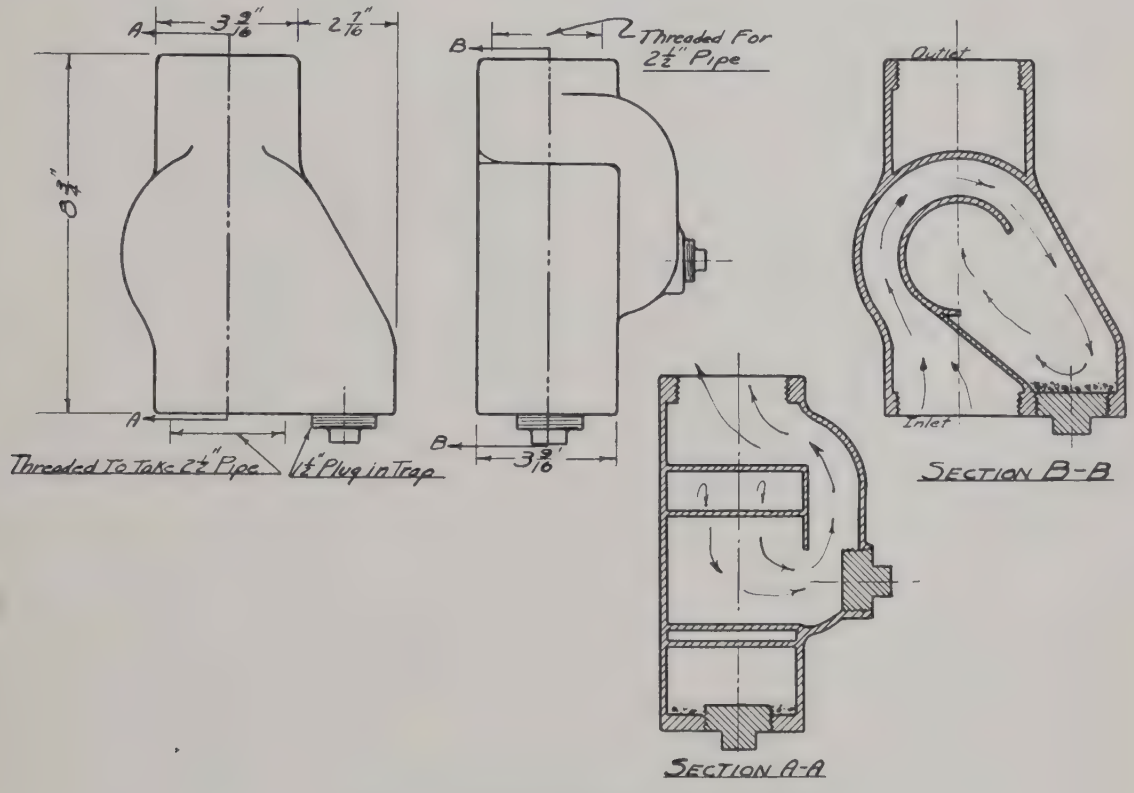


Fig 15.—Caterpillar spark arrester.

The back pressure was 4.75 inches of water for the arrester without screens and 5.75 inches when the screens were applied (table 10).

The Caterpillar Spark Arrester.—This arrester consists of a one-piece iron casting (fig. 15). It works on the same principle as the cyclone, except that the exhaust gas is carried through an additional 270° and discharged in line with the entrance after the carbon particles have been separated from the gas stream. The arrester, therefore, can be located close to the manifold; and a tail pipe can carry the gas away. No beneficial results, as far as separating the carbon is concerned, are gained in turning the exhaust gas through the last 270°.

The efficiencies were 94.0, 93.3, and 77.0 per cent, respectively, for carbon sizes 2, 3, and 4 (table 11). The back pressure amounted to 12.15 inches of water (table 10).

A field study of this arrester showed that very little carbon was eve retained in the trap. The reason might possibly have been the nearnes in some cases, of the arrester to the exhaust manifold, resulting in ten peratures high enough to ignite the carbon. The most likely explanation however, is that the space provided for collecting the carbon is to small; after a small amount of carbon accumulates, the rest is gradually carried out in the exhaust stream.

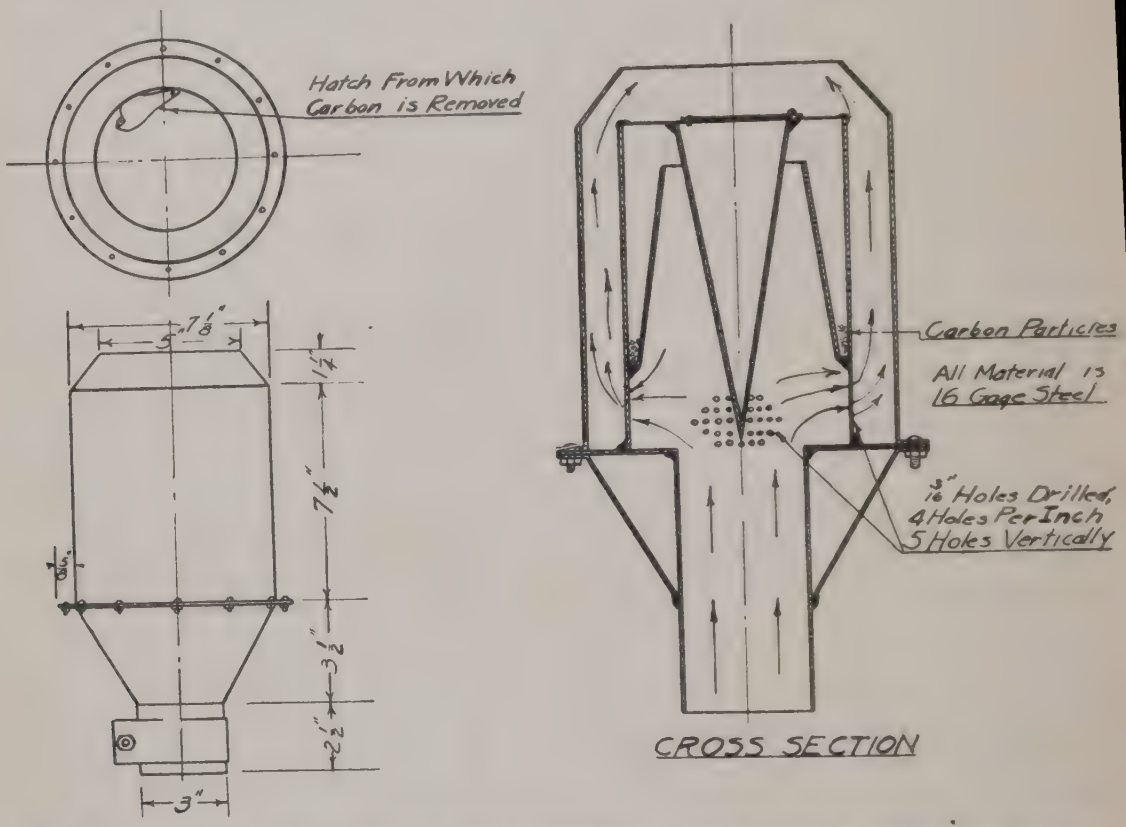


Fig. 16.—Funke experimental spark arrester. (Cross section drawn on one-half larger scale.)

The Funke Spark Arrester.—An experimental arrester (fig. 16) designed and built by F. W. Funke, Senior Forest Ranger, U. S. Forest Service, showed considerable promise. An outer cylinder is enclosed at the lower end and tapered to a 5-inch outlet at the top; and an inner cylinder, concentric with it, is enclosed at the top and opens at the bottom directly into the exhaust pipe. A series of 3/16-inch holes, four per inch horizontally and five vertically, near the base of the inner cylinder permit the gas to flow into the outer cylinder and thence to the outside. A cone centered and attached, inverted, to the top of the inner cylinder splits the stream of carbon particles, directing them through an opening made between it and the walls of the frustum of another cone. The latter frustum is open at both ends, with the larger end attached to the inside wall of the inner cylinder 2 inches from its base. The two cones

taper toward each other, providing at their closest point an opening of ½ inch (fig. 16).

Upon entering the arrester, the carbon particles, because of their inertia, continue in a straight line until deflected by the inverted cone, while the gas turns more or less abruptly, flowing through the holes in the side of the inner cylinder. Having passed the narrow opening between the two cones, the carbon particles fall into a space formed by the

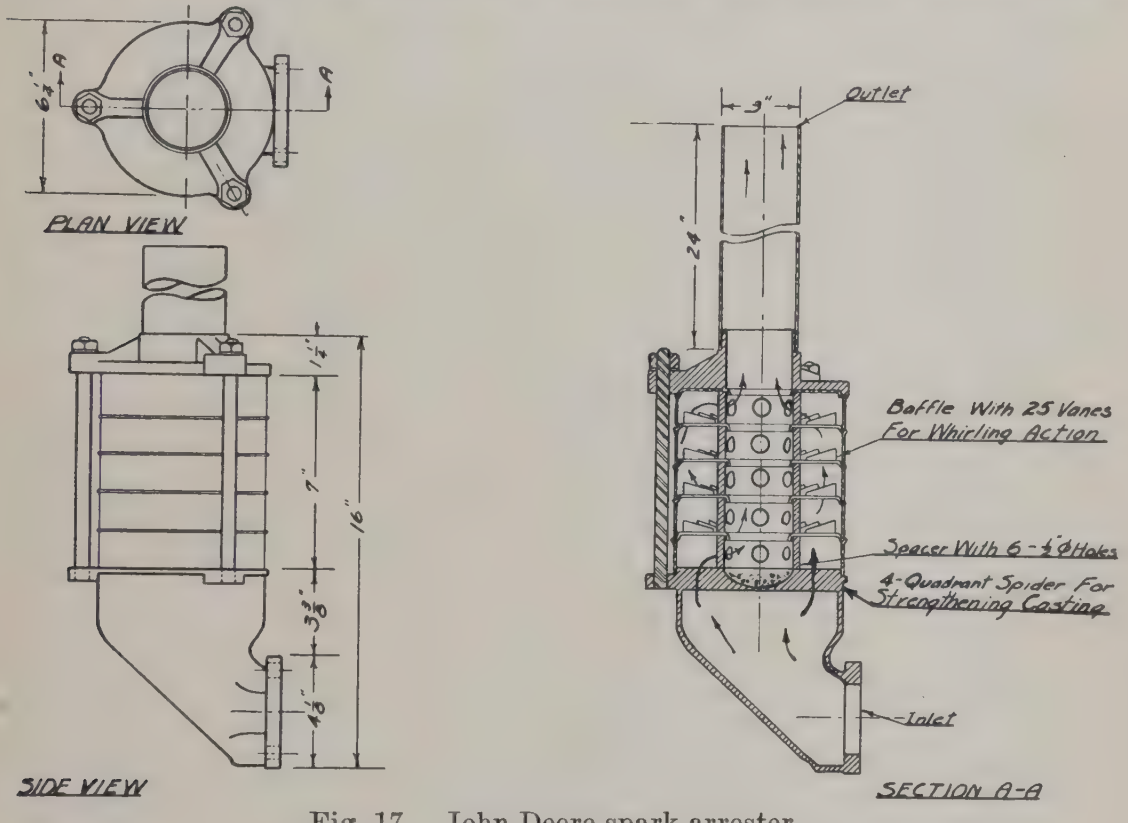


Fig. 17.—John Deere spark arrester.

outside wall of the frustum of the cone and the inside wall of the inner cylinder, in the top of which an opening with a removable covering permits one to clean the entrapped carbon from the arrester.

The efficiencies were 99.9, 96.0, and 94.3 per cent, respectively, for carbon sizes 2, 3, and 4 (table 11). The back pressure amounted to 2.75 inches of water (table 10).

The John Deere Spark Arrester.—Though not in the inertia group, the John Deere arrester does resemble inertia types, in that the gas is set into a swirling motion by the use of vane-type baffles between the different sections.

This arrester (fig. 17) is made up of similar sections superimposed, each consisting of a central spacer with six holes equally spaced around the periphery to permit passage of the gas between the outer and inner chambers, and with an outer shell. A baffle, with twenty-five vanes which impart a swirling motion to the gas, forms the top of each section, be-

tween the central spacer and the outer shell. The arrester consists of five such sections, each slightly telescoped together, held between two castings. The bottom casting is so shaped that it can be connected to the exhaust manifold, while the top one provides a connection for a tail pipe to carry the gas away from the engine.

The lower end of the inner cylinder, formed by the five spacers, is tight, so that the gas passes through the holes in the spacer, between the outer and inner chambers. After reaching the first section, the gas has two possible paths: it may pass immediately through the holes in the first spacer into the inner chamber, whence it is free to go into the open; or it may travel vertically from one section to the next, passing through the baffles between each section until the last is reached, and then leaving the arrester through the inner chamber. The gas is set into a swirling motion by the baffles as it goes from one section to the next. Some carbon remained in the lower end of the inner cylinder at the end of a test, but much passed out of the arrester with the exhaust gas, as the tests indicated. Obviously, in the design of this arrester, no place is provided for the retention of carbon material.

The efficiencies were 17.6, 17.9, and 11.8 per cent for carbon sizes 2, 3, and 4, respectively (table 11). The back pressure amounted to 4.25 inches of water (table 10).

TESTS OF SCREEN-TYPE ARRESTERS

The McCormick-Deering Spark Arrester.—This device (fig. 18) is so constructed that the exhaust gases must pass through two thicknesses of 10-mesh, No. 20 iron-wire screen, twice before they are discharged. Any carbon material smaller in diameter than the size of screen opening passes through the arrester with the gas. The coarser carbon material remains in the exhaust line, pounding about till its size has been reduced sufficiently to pass the screen.

The openings in the two layers of screen do not always coincide; and, since they are rather loosely held together, carbon particles are sometimes caught and held between the screen walls, especially near the point. Any large amount retained by the screen increased the restrictive effect of the arrester. For example, when a 100-gram sample of size 2 carbon was gradually introduced into the line, the back pressure increased from 10.5 inches of water at the beginning of the test to 76.07 at the end, while the pulley speed dropped 20 revolutions per minute. On the other hand, when a test was run with No. 4 carbon, the back pressure increased only 2.1 inches of water (table 10). In the latter case, most of the carbon was small enough to pass through the screen, and the speed did not fluctuate to any great extent.

Sometimes, under operating conditions, the carbon caught and held between the screen layers and inside the cone tip may catch fire because of the high temperatures of the exhaust gas. Thus the lower tip may burn off, decreasing the efficiency of the arrester. This tendency was reported in one case.

The efficiency was 100, 99.9, and 18.5 per cent, respectively, for carbon sizes 2, 3, and 4 (table 11).

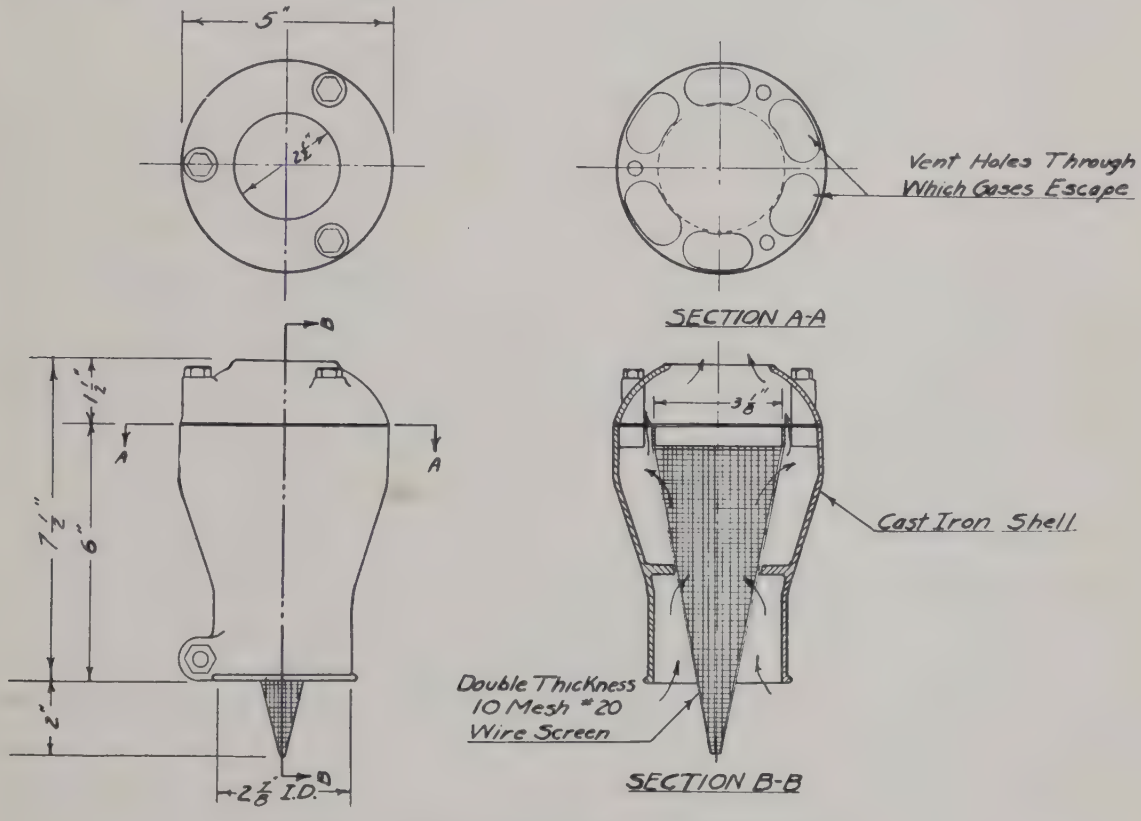


Fig. 18.—McCormick-Deering spark arrester.

Experimental Spark Arrester.—An experimental device of the screen type was built up primarily to test screens of different composition for resistance to heat and vibration. It consisted of a pipe, 4 inches in diameter and 30 inches long, made of 18-gauge black steel (fig. 19). The upper end was closed off; and three rows, each including nine 1-inch holes, were drilled around its circumference. The first row was 1 inch below the top of the pipe; and the next two rows were 3 inches and 5 inches, respectively, below the top. A shell of the same weight steel, 8 inches in diameter and 9 inches long, was placed concentric with the upper end of the pipe. This shell was closed around the pipe 2 inches below the bottom row of holes. Its top extended 2 inches above the end of the center pipe and had an opening 5 inches in diameter, covered with 16-mesh, No. 1 Nichrome wire screen. The size of the wire in the screen was 0.019 inch, which gave a net opening of 48 per cent of the total area. The screen had a total area of 19.6 square inches, with a net

opening of 9.4 square inches. It was held in place by an annular plat bolted to the top of the shell.

The efficiency of this arrester was 100, 100, and 71 per cent for carbon

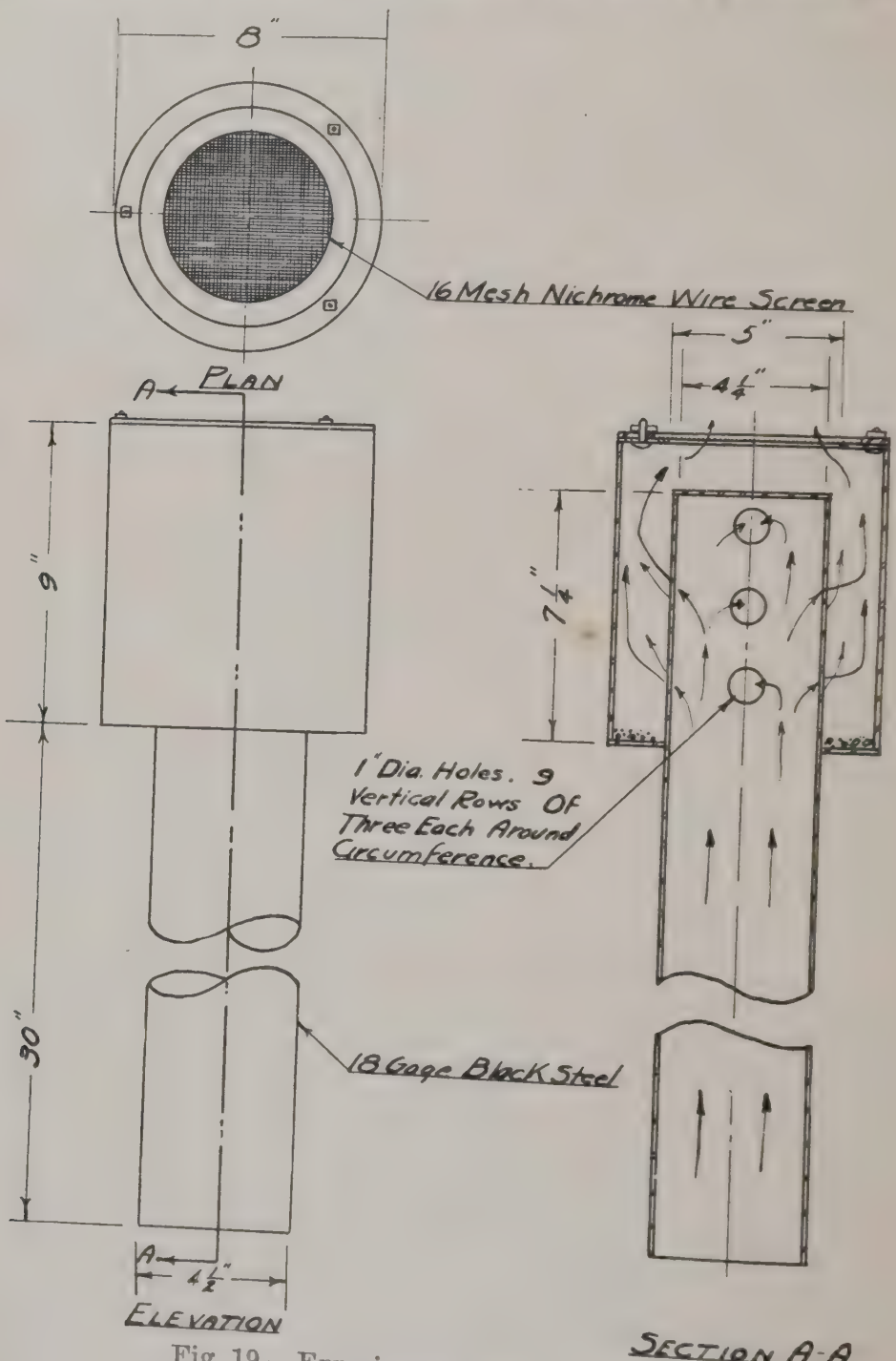


Fig. 19.—Experimental spark arrester.

sizes 2, 3, and 4, respectively (table 11). The back pressure created amounted to 2 inches of water (table 10).

The Case Harvester Arrester.—The Case arrester (fig. 20) consists of a pipe closed off at the upper end and having six vertical rows of ½-inch holes punched near the upper end. The outer shell is 5¼ inches in diam-

eter and 11 inches long, with a closed top and with a 2-inch opening in the bottom for slipping over the end of the inner pipe. Lugs on the pipe 11 inches from the top, and a bolt through the top of the outer shell and

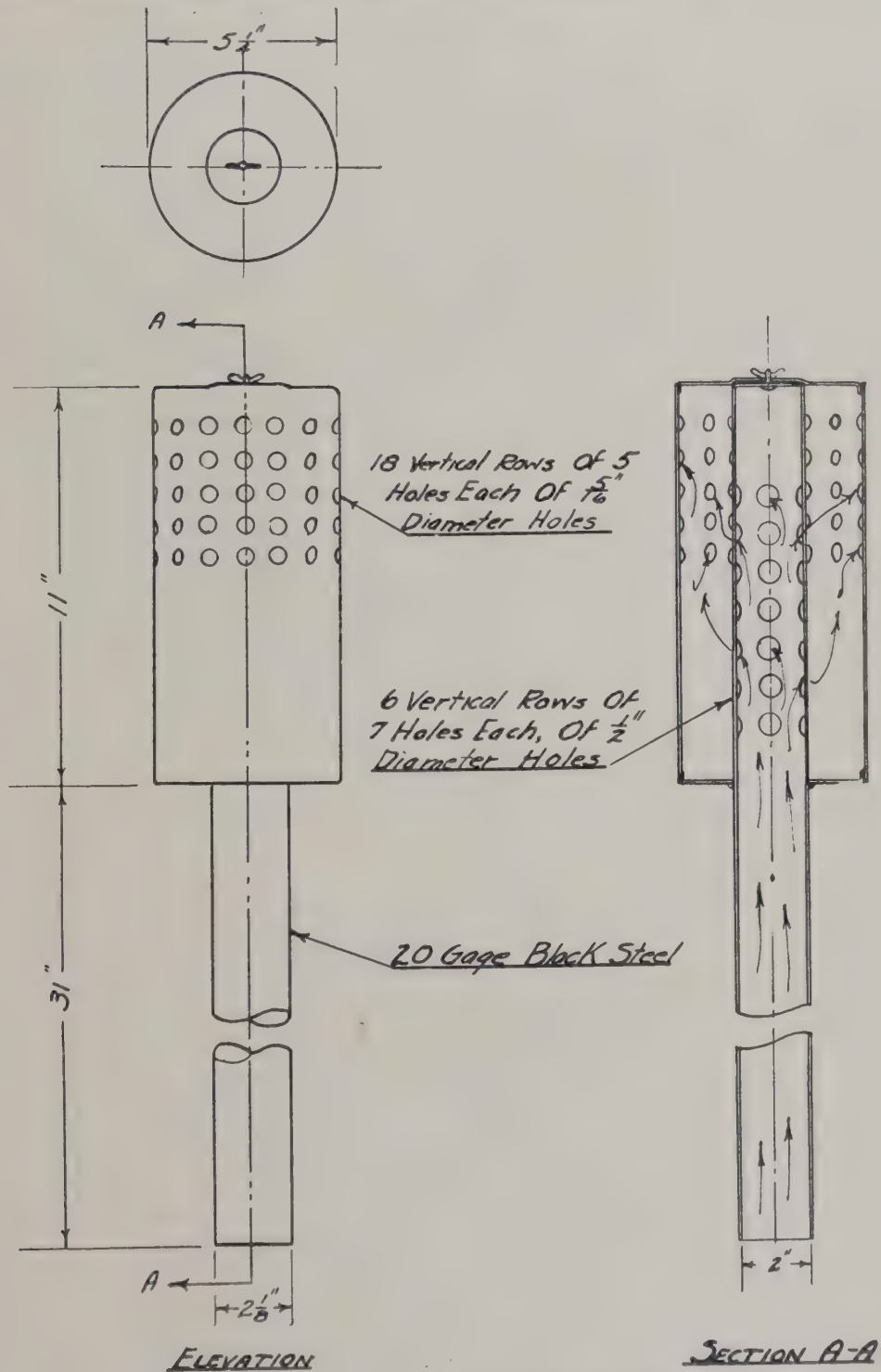


Fig. 20.—Case spark arrester for combines.

the end of the pipe, keep the outer shell concentric to the pipe. A series of eighteen vertical rows of five holes each, 5/16 inch in diameter, extend through the outer shell. The top holes are 1 inch from the top of the shell and extend down 4 inches.

As some of the holes through the pipe are in line with the holes in th outer shell, obviously carbon can pass directly through the arrester.

The efficiency of the Case arrester was 82.6, 64.6, and 41.4 per cen

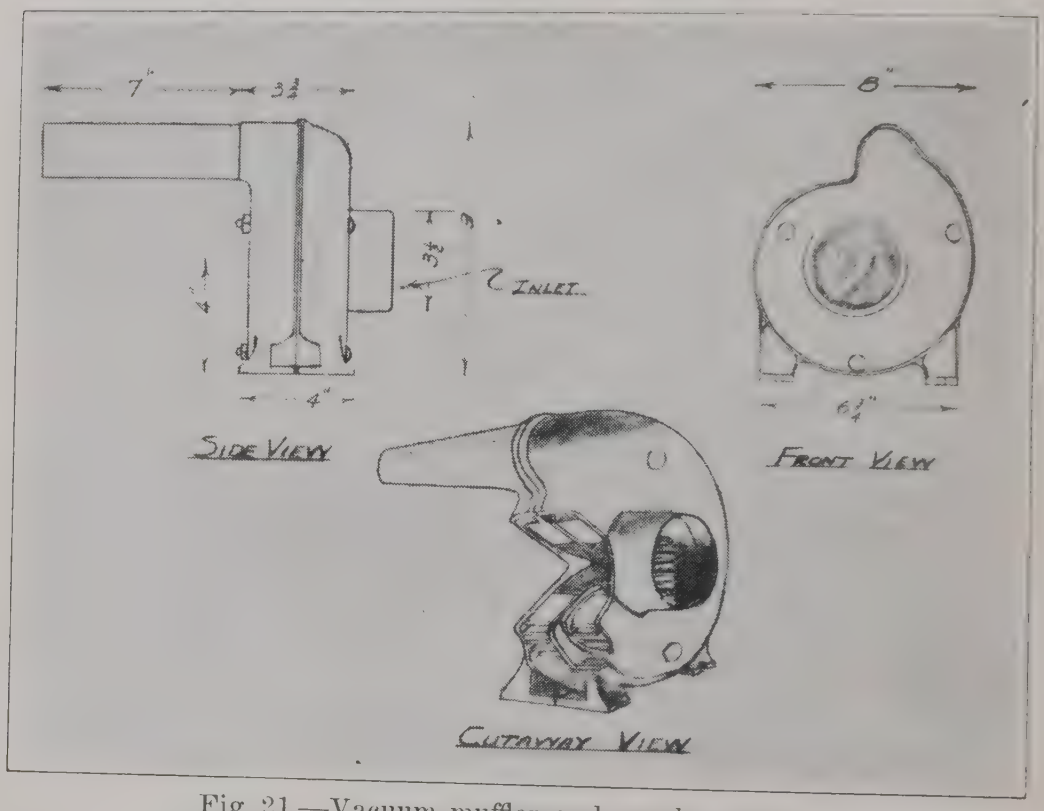


Fig. 21.—Vacuum muffler and spark arrester.

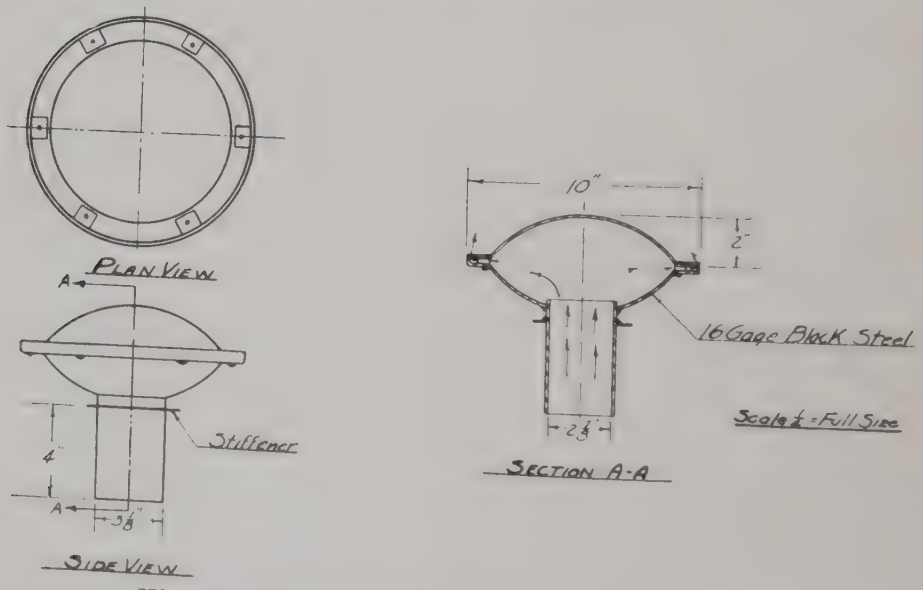


Fig. 22.—Hercules muffler and spark arrester.

for carbon sizes 2, 3, and 4, respectively (table 11). The back pressure amounted to 4.75 inches of water (table 10).

The Vacuum Muffler and Spark Arrester.—The Vacuum device (fig. 21) consists of a somewhat intricate casting. The outer shell, cast in two

parts, is held together by three bolts. The shell is 4 inches wide and 8 inches in diameter, having at the center an inlet 3½ inches in diameter. The outlet is near the outer edge on the opposite side from the inlet.

TABLE 10

BACK PRESSURE CAUSED BY VARIOUS ARRESTERS

Name of arrester	Back pressure at beginning of test	Back pressure at end of test
	inches water	*inches water*
Yuba (original)	4.25	4.25
Yuba (modified)	1.75	1.75
Cletrac cyclone	4.75	4.75
Cletrac cyclone (with screens)	5.75	5.75
Experimental	2.0	2.0
McCormick-Deering	10.5	76.07*
Vacuum	5.35	5.35
Funke	2.75	2.75
Case Harvester	4.75	4.75
John Deere	4.25	4.25
Hercules	5.35	15.55†
Caterpillar	12.15	12.15

* Test in which size 2 carbon was used. Back pressure at end of test for size 3 was 48.9 inches water, at end of test for size 4 carbon, 12.6 inches water.

† For size 2 carbon only. Back pressure for sizes 3 and 4 carbons at end of test, same as for beginning.

TABLE 11

EFFICIENCY OF SPARK ARRESTERS, IN PER CENT

Arrester	Carbon size No. 2	Carbon size No. 3	Carbon size No. 4
Yuba	98.0	96.8	69.3
Modified Yuba	99.6	99.3	97.6
Modified Yuba (horizontal)	98.3	97.7	94.4
Modified Yuba (variable load)	99.9	99.6	98.7
Cletrac cyclone	98.7	98.2	79.0
Cletrac cyclone (screened)	100.0	99.9	80.2
Caterpillar	94.0	93.3	77.1
Funke	99.9	96.1	94.3
Funke (variable load)	99.9	99.6	98.2
John Deere	17.6	17.9	11.8
McCormick-Deering	100.0	99.9	18.5
Experimental	100.0	100.0	58.7
Case Harvester	82.6	64.6	41.4
Vacuum	81.7	28.2	15.3
Hercules	83.0	18.5	9.5

Twenty finger-like projections 1½ inches long, cast integral with the side walls, extend toward the middle of the arrester; and two other flat castings with similar fingers are located in the middle. The fingers on the inner walls and on the flat casting dovetail together, leaving a small clearance for the passage of gas and, at the same time, preventing carbon particles from passing until their size is approximately No. 3.

The path of the gas through this arrester is into the center of one side, then through the space between the fingers, and thence to the outlet. There is no place for carbon particles to be retained. If too large to pass the small clearance between the fingers, they remain in the exhaust line until reduced sufficiently to pass through between the fingers.

The efficiency was 81.7, 28.2, and 15.3 per cent for carbon sizes 2, 3, and 4, respectively (table 11). The back pressure amounted to 5.35 inches of water (table 10).

The Hercules Muffler.—This muffler (fig. 22), used occasionally as a spark arrester, consists of two stampings from 16-gauge steel riveted together to form a 4 × 10 inch dome-shaped chamber. A small space between the two halves of the arrester provides passageway for the gas and the smaller carbon particles (including size 3).

The efficiency of this arrester was 83.1, 18.5, and 9.5 per cent for sizes 2, 3, and 4, respectively (table 11). The back pressure amounted to 5.35 inches of water under normal operating conditions, but increased to 15.55 after 100 grams of size 2 carbon particles had been introduced into the exhaust line. On the coarser carbon material the arrester tended to load up, causing greater restriction (table 10).

FIELD TESTS OF ALLOY SCREENS

Common 16-mesh window screen is often placed over the end of exhaust pipes of tractors and trucks to stop the discharge of carbon material. Since iron screens rust and burn out when subjected to the heat from exhaust gases, frequent replacements are necessary. Observations made on one harvester equipped with a screen type of arrester showed three replacements of screen within a week. This screen is liable to burn out without the operator's knowledge, presenting, until replaced, the fire hazard of an unprotected exhaust system. In its use, little attention has been given to proper openings (screen area) to insure that the velocity of exhaust gases, through the screen, will be sufficient to keep the screen relatively free from a carbon coating. For example, the screen type of arrester that was standard equipment on Harris harvesters had a screen area of approximately 113 square inches. As the gas velocity was too low to keep the surface clean, carbon collected on the screen; and later, when the engine was working under a heavy load, the carbon caught fire and was carried away still burning.

An experimental arrester (fig. 19), on which the screen area over the final opening was approximately one-sixth that of the regular Harris arrester, was used to replace the latter. The back pressure on the exhaust system increased only 0.2 of an inch of water in consequence of the

change. At the same time the screen was found to remain free of carbon coating because of the higher velocity of the gases through it.

An attempt was made to find an alloy screen that would withstand the heat and vibration of the exhaust gases. Two such screens, 16 meshes per inch, were selected—namely, "Chromel" and "Nichrome" (trade names for nickel and chromium alloys). Chromel A and Nichrome 4 are identical, containing 80 per cent nickel and 20 per cent chromium. The cheaper grades contain small amounts of iron, which lowers their resistance to heat and vibration, disqualifying them for this type of work. Chromel A or Nichrome 4 withstands these conditions better than other combinations in these series.

An experimental arrester employing Chromel A, 16-mesh screen, having a 46 per cent net opening, showed no signs of failure after 560 hours of use. It was attached to the exhaust pipe of a 30-hp. tractor, only 10 inches from the exhaust manifold, so that the conditions were rather severe.

Failure occurred in 130 to 180 hours of operation when the lower grades of alloy screens, containing iron, were used.

TEMPERATURE EFFECTS FROM COVERING EXHAUST PIPES

A piece of seamless steel tubing, 1¾-inch outside diameter, 8 feet long, was attached to the exhaust manifold of a 22-hp. 4-cylinder engine, 4-inch bore, 4½-inch stroke, operating at 1,170 r.p.m., pulling its rated load. The temperature of the gases in the manifold was 1000°; at the end of the line, 598°. The temperature on the surface of the pipe was 590° at points 2 and 5 feet from the manifold.

The tubing was then wrapped with engineer's tape (asbestos, 7/16 inch thick, 2½ inches wide), and the temperatures were noted at the same points as above. The temperature in the manifold was 985°; at the end of the line, 728°. On the surface it was 320° at 2 feet and 270° at 5 feet from the manifold. Though the coverings materially reduced the surface temperatures, the temperatures of the gases at the end of the line were considerably higher.

The tape was then replaced by a 3-inch galvanized iron pipe, held equidistant from the tubing, giving a clearance of approximately ⅝ inch between the tubing and the pipe. The temperatures of the gases in the manifold and at the end of the line were 975° and 760°, respectively, while the surface temperatures were 200° at 2 feet and 185° at 5 feet from the manifold.

A third pipe 4 inches in diameter was placed around the 3-inch pipe and held equidistant from it. This pipe remained so cool during the test that it did not burn bare hands.

When the 3-inch galvanized pipe was used over the 8-foot length of tubing, in a vertical position, the temperatures along the surface 2 and 5 feet from the manifold were 160° and 140°, respectively, because of natural convection through the space between the two pipes. Since both ends of the 3-inch pipe were open, air circulated freely through it.

EFFECTIVENESS OF MUFFLERS AS SPARK ARRESTERS

A few preliminary tests were run on two mufflers to determine whether or not carbon particles were separated from the exhaust gases. In some cases the carbon was retarded by the muffler; but very little was held permanently. In other words, when carbon was introduced into the line ahead of the muffler, some passed through immediately, the rest at intervals ranging from a few seconds to several minutes.

A test, previously reported, in which a car was treated for carbon removal, revealed that the carbon particles passed through the muffler and tail pipe at temperatures sufficiently high to set cotton batting on fire. The batting was held 18 inches back of the tail pipe. To produce the same results, engine scrapings size 4 had to be heated to a temperature of 1400°.

In general, the average muffler cannot be considered a satisfactory spark arrester. No doubt it assists somewhat, especially in cooling the particles.

SUMMARY

The amount of carbon ejected with the exhaust gas, for the average tractor engine, varies from less than 0.1 gram to 1.0 gram per hour, according to the condition of the engine. On the average, 50 per cent of this carbon is of a size that will not pass a 28-mesh screen. Since the kindling temperature for this carbon varied from 887° for size 5 to 1022° for size 2, evidently carbon can be ignited by the temperatures existing in the exhaust system of an internal-combustion engine.

Fires can be consistently started in dry vegetation, by carbon particles, sizes 1, 2, and 3 (see table 2 for the sizes of carbon samples) with initial temperatures of 1500° to 1600°, during the normal summer conditions in California. In extremely warm dry weather, fires may be started with these sizes at temperatures as low as 1300°.

Fires can be started by size 4 with an initial temperature of 1500°, under conditions favorable to fire.

Carbon size 5, when heated to an initial temperature of 1500°, can start a fire in dry grass on extremely hot dry days. This size of particle, however, lost its heat so rapidly that it ceased to glow within a distance of 9 feet from the furnace, when heated to an initial temperature of

1800°. In practice, therefore, the exhaust pipe could be turned up, discharging into the air, thus providing the necessary distance for cooling the smaller particles before they reach the ground.

The tendency for brush-field and pine-needle litter to be ignited by carbon sparks is about the same. Both catch fire less easily than dry grass. Punk, however, was found not only to be readily ignited but to cause "hang fires"; that is, the material did not blaze immediately, but continued to smoulder and finally burst into flame. In one case the time was 40 minutes.

Exhaust pipes having surface temperatures of 1200° may start fires upon contact with dry grass. Surfaces with temperatures as low as 838° may ignite dry vegetation after several minutes of contact, which could occur if dry grass or straw lodged on an exhaust manifold. If the surface shows even the slightest red color, when viewed at night, it is dangerous and the part should be so placed or guarded that it will not touch vegetation.

Several commercial spark arresters now on the market were above 95 per cent in efficiency in stopping carbon sizes 2 and 3; but all were 80 per cent or below in efficiency for size 4.

One commercial arrester was below 20 per cent in efficiency for all sizes of carbon.

The efficiency of one arrester was increased from 69.3 to 97.6 per cent, for size 4 carbon, by a slight modification in design.

One experimental arrester had an efficiency of 93 per cent or higher for carbon sizes 2, 3, and 4.

The arresters with the highest efficiency created the least back pressure on the exhaust system.

The average muffler cannot be considered a satisfactory spark arrester. No doubt it assists somewhat, especially in the cooling of particles.

Iron screen over the exhaust pipe presents considerable danger, as holes may burn through without the operator's knowledge, thus presenting a fire hazard from an unprotected exhaust system until replaced. Alloy screens consisting of 80 per cent nickel and 20 per cent chromium stood up much better than iron screen. The cheaper grades of these alloy screens, however, contain varying amounts of iron and are, therefore, unsuitable for this type of apparatus.

ACKNOWLEDGMENTS

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Senior Forest Ranger, U. S. Forest Service, for assisting in the development of experimental arresters and for collecting and supplying carbon for field trials; and to O. C. French, Junior Agricultural Engineer, University of California, for assisting in the work relative to burning, and with the efficiency tests of spark arresters, and for preparing all drawings of the spark arresters. In addition, the authors are grateful to Roy Owens, of Red Bluff, and Albert Mohr, of Cottonwood, for permission to carry on investigational work in their fields.

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THE TANK-MIXTURE METHOD FOR DORMANT OIL SPRAYING OF DECIDUOUS FRUIT TREES IN CALIFORNIA

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THE TANK-MIXTURE METHOD FOR DORMANT OIL SPRAYING OF DECIDUOUS FRUIT TREES IN CALIFORNIA[1, 2]

ARTHUR D. BORDEN[3]

MARKED ADVANCEMENTS have been made during the past ten years in the use of dormant oil sprays in the spraying of deciduous fruit trees in California. The order of progress has included crude-oil emulsions, mechanical mixtures, distillate emulsions, miscible oils, and finally the paste-type emulsions in general use at the present time.

The fact is well established that oil spray is superior to liquid lime-sulfur solutions in the control of San Jose scale (*Aspidiotus perniciosus* Comst.) and other scale insects, and also that it is very effective in destroying the egg masses of the fruit tree leaf roller (*Cacoecia argyrospila* Walk.). The penetrating and spreading characteristics of the oil insures better results than can be obtained with the lime-sulfur wash. In addition to being more effective, oil sprays are easier to handle and apply, and cost less than lime-sulfur.

Crude-oil emulsions and miscible-oil emulsions are now rarely if ever used on deciduous fruit trees in California. The paste-type emulsions have replaced these and have advantages such as safety, economy, and ease of handling. But with this progress have come new problems pertaining to the type of oil and the kind and amount of emulsifier required to give the most satisfactory results. Since attention has been paid to the type of oil used in the emulsions and the oil-depositing quality of the spray, the chance of injury to dormant deciduous trees is small. The safety of the dormant spray oils is largely dependent upon the sulfonation and the viscosity of the oils. The only precautions now practiced in the use of dormant oil sprays are that the early applications are not made before the trees are dormant nor before enough rain has fallen in the early winter to wet the soil sufficiently, and that the late applications are not made after the "green tip" stage of the bud. In general, in northern California the dormant sprays are applied in the months of January and February.

[1] Received for publication November 23, 1933.

[2] The writer wishes to express his appreciation to E. L. Wampler, graduate student in Entomology, for his assistance in these experiments.

[3] Assistant Entomologist in the Experiment Station.

The fruit grower is often confused by the many brands of emulsion offered him and by the claims made by some salesmen. Too frequently the price alone may be the deciding factor. Seasonal changes in the formulas by the manufacturers, and a change of brands by the grower are often responsible for notable differences in efficiency. These, together with the ever present difficulty of obtaining sufficient coverage in making the application, may prevent satisfactory control.

QUALITIES OF OIL SPRAY

There are certain special terms used in describing oil sprays which may be explained at this point.

Spray oils are one type of product obtained in the distillation and purification of crude oil. The crude oil is placed in stills and, under partial vacuum, is heated to successively higher temperatures. Spray oils are the less volatile fractions which come over after the lighter stove distillates and before the heavier lubricating oils.

The purification process is accomplished by removing the undesirable unsaturated and aromatic hydrocarbons, which are regarded as impurities, by treating the distillate with liquid sulfur dioxide or after subsequent treatment with strong sufuric acid. The unsaturated and aromatic compounds are removed as a heavy dark sludge. The purified oil is neutralized by washing with an alkaline solution and is then thoroughly washed with water. It is later dried by blowing air through the oil.

The unsaturated and aromatic hydrocarbons are particularly injurious to trees, and therefore the safety of an oil depends on the extent to which these compounds are removed. The purity of a spray oil is determined by the percentage that remains unchanged when subjected to the sulfuric acid test, known as the sulfonation test. Dormant spray oils generally show an unsulfonation of from 60 to 74 per cent.

Spray oils have been classified as light, light-medium, medium, and heavy, on the basis of viscosity and distillation. The viscosity pertains to the flow of the oil and is expressed as the number of seconds required for 60 cubic centimeters at a temperature of 100 degrees Fahrenheit to flow through a small orifice in an instrument known as the Saybolt Universal viscosimeter.

The distillation range gives the minimum and maximum temperatures between which the distillation takes place and the percentage of oil distilling over at certain temperatures within the range.

A "straight-cut" oil is one derived from distillation within certain definite ranges of temperatures and is not a blended oil.

Blended oils are those in which an oil of a lower viscosity and distillation range has been mixed or blended with one of a higher viscosity and distillation range. The viscosity of such a blended oil is not particularly indicative of the properties of such a product. The distillation reveals the nature of such an oil.

A spray oil emulsion usually consists of from 80 to 85 per cent spray oil, which has been formed into a stiff paste by the addition of an emulsifier and water. The common emulsifiers used are ammonia caseinate, petroleum soaps, etc. The use of such emulsifiers usually insures the stability of the emulsion and the suspension of the oil particles when diluted in water. In general there are two types of emulsions: the quick-breaking and the "tight" emulsion. In the former type a minimum amount of emulsifier is used and the oil globules are less securely held in the dilute spray so as to produce a higher percentage of oil deposit when the spray strikes the bark or foliage of a tree. This type is more desirable and efficient than the more stable emulsions called tight emulsions, in which the oil droplets are more securely held by the emulsifier and deposit comparatively low percentages of oil.

The oil-depositing, wetting, and spreading properties of any spray are of much importance. A spray may overcome the resistance of the bark or foliage of a tree to wetting and yet deposit but comparatively little oil. Much of the oil may be lost in the runoff, or drip, from the tree. On the other hand, a minimum amount of wetting and spreading is essential to give a quick, even distribution of the oil deposited.

COMMERCIAL OIL EMULSIONS

In northern California at present, nearly a score of commercial oil emulsions are offered to the growers for use in the dormant sprays. Many of these are excellent emulsions made from refined lubricating oils with different types of emulsifiers. The results of studies indicate that some of these emulsions contain undesirable blends of oils, while others are made from oils that are too low in purity. The greatest difficulty lies in the wide variance in the oil-depositing properties of the different emulsions. The so-called "tight" emulsions deposit a very low percentage of oil and allow too much of the oil to be lost in the runoff. Other emulsions of a quick-breaking type deposit a comparatively heavy film which is much more desirable.

The oil-depositing quality of the spray bears an important relation to the dosage of oil that is required to give effective control. This quality is determined by the kind and amount of emulsifier contained in the emulsion or the spray mixture in the tank. Manufacturers of emulsions have apparently given this important point but little consideration.

The results of laboratory tests on the amount of oil deposited on 2[illegible] square inches of waxed surface by 14 brands of commercial oil emulsions are shown in table 1. In each test the spray was a 5 per cent emulsion. Each test was repeated ten times in order to obtain an average which may be regarded as reasonably correct. The exposure to the spray was for 15 seconds.

In table 1 the wide variation in the oil-depositing properties of the commercial oil emulsions is shown. Emulsion No. 13, which shows the lowest oil deposit, is sold for the same purposes and is recommended to

TABLE 1

OIL DEPOSITS OF COMMERCIAL OIL EMULSIONS

Brand No.	Oil deposit in milligrams	Brand No.	Oil deposit in milligrams
1	33	8	47
2	24	9	28
3	25	10	42
4	37	11	40
5	55	12	23
6	51	13	22
7	54	14	48

be used at the same dosage as emulsion No. 5, which shows the highest deposit. A manufacturer may sell three or more brands of emulsions to be used at the same dosage, and yet the emulsions may differ widely in oil deposits.

The changing of the type or amount of emulsifier used in the manufacture of emulsions naturally changes the properties of the emulsion. These changes may sometimes occur during a season, and the user of the material may not be aware of the difference in the product.

At the request of deciduous fruit growers in northern California, the investigation of dormant oil emulsions was begun in 1930 by the University of California to determine what type of an emulsion gives the highest efficiency, and why more uniform results are not obtained in the orchard.

The success of the tank-mixture method in spraying citrus trees in southern California was very marked, and its application to deciduous fruit trees in northern California remained a comparatively new field. An earlier attempt to use certain oil and calcium caseinate spreader without proper agitation in Santa Clara County had started a few growers to use these materials, but much more study was necessary to make it a safe practice. The economic situation in the fruit industries also made it necessary to lower costs of insect control. A solution to both

problems, that of obtaining a higher uniform efficiency, and saving on cost of materials, was offered by the tank-mixture method.

In the development of this method an available supply of the proper type of oil and spreader was required and, most difficult of all, the agitation necessary to give a uniform mixture in the spray tank had to be developed. Through the coöperation of four major oil refineries, a supply of oil was made available. Careful laboratory and field tests soon

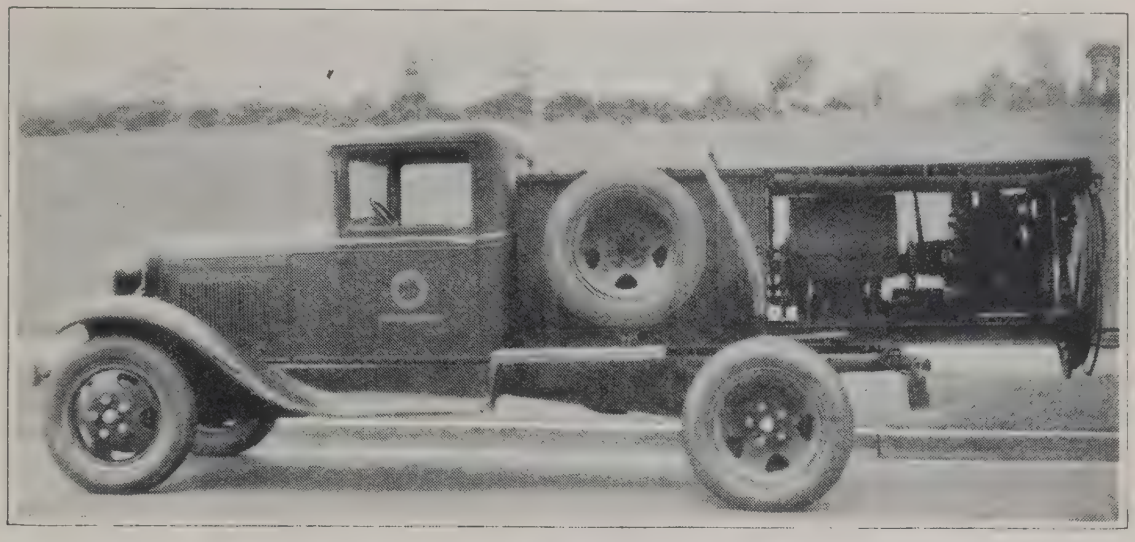


Fig. 1—The University of California Agricultural Experiment Station spray equipment used in this investigation.

showed that blood albumin spreader used in southern California was the best spreader.

The matter of procuring adequate agitation in the comparatively low-powered spray equipment of our deciduous orchards was a problem. The high speed (200 r.p.m.) agitation, as recommended in the citrus orchards, was excellent for equipment with 8-hp. motors or above, but to add this ½-hp. requirement for agitation to the outfits using 3 or 4-hp. motors and yet maintain a satisfactory pressure at the pump was almost impossible. The solution of this problem was found in changing the type of agitators in the spray tank, as is shown in the section "Spray-Tank Agitation."

THE TANK-MIXTURE METHOD

The following procedure shows the difference in the use of commercial oil emusions and the tank-mixture method: Instead of buying the emulsion in the paste form in steel drums and adding it in proper proportions to the water in the spray tank, the grower buys the spreader and spray oil and adds them separately to the water in the spray tank, and a uniform mixture is produced and maintained by the agitators.

The usual method employed is to fill the tank with water up to, or above, the agitator shaft, start the motor and agitation, sift in the spreader, and add the oil as the tank is filling with water. Proper agitation is essential and no sprayer should be used until the requirements given under "Spray-Tank Agitation" have been met.

The advantages of the tank-mixture method are that it is possible to obtain materials of definite known quality, purchased upon specification, free from blends, and at a saving of approximately 50 per cent in cost. The oil-depositing property of tank-mix spray is higher than that of the commercial oil emulsions and, therefore, a lower dosage may be used. The ease and accuracy in measuring and handling the materials appeals to most growers, and the spreading and wetting properties of the spray are equal, or superior, to those of any commercial oil emulsion.

A comparison of the costs for dormant spraying for the season of 1932-33, as recommended for San Jose scale control is shown below:

Commercial oil emulsion:		
5 gallons emulsion per 100 gallons dilute spray at $0.18		$0.900
Tank-mixed method:		
3 gallons oil per 100 gallons dilute spray at $0.10	$0.300	
4 ounces spreader per 100 gallons dilute spray	0.055	$0.355
Saving per 100 gallons dilute spray		$0.545

Another important factor is that the tank-mixture spray is compatible in combination with bordeaux mixture, or lime-sulfur, or caustic soda. This makes possible a combination spray which may serve a dual purpose. Tank-mix spray is apparently not affected by the hardness of spray water.

OILS EMPLOYED

In the orchard experiments conducted the past two seasons with the tank-mixture method, three types of nonblended (straight-cut) dormant oils were employed to determine comparative values for scale kill and possible injury to fruit buds. These oils were:

Grade	Unsulfonated residue	Viscosity Saybolt at 100° Fahrenheit
Brown Neutral	55–65	100–110 seconds
Tank Mix Grade B	65–70	100–120 seconds
Tank Mix Grade A	70–75	100–120 seconds

Blends of other oils were made to give viscosities of 70, 120, 140, 160, and 200 seconds Saybolt at 100° Fahrenheit.

No injury to the fruit buds of apple, pear, or prune was noted from the application of any of the oils used except on prune, where the two higher viscosity blends (160–200 seconds) when applied late delayed the blooming time fully one week.

No appreciable difference was noted in the control of San Jose scale or brown apricot scale (*Lecanium corni* Bouche) in any of the applications with oils of from 100 to 120 seconds viscosity.

The results thus far obtained permit recommending the Tank Mix Grade A oil of 70 per cent or above in unsulfonated residue and with a viscosity of from 100 to 120 seconds Saybolt 100° Fahrenheit for all dormant tank-mixture work. Spray oils of these specifications are available from the following oil companies:

Associated Oil Co.	Avon 100 Spray Oil
Shell Oil Co.	Dormant Spray Oil No. 11
Standard Oil Co.	Calol Dormant Spray Oil
Union Oil Co.	Dormant Spray Oil 3—110—70

SPREADER FOR THE TANK-MIXTURE SPRAY

In the earlier attempts at emulsifying dormant oils a calcium caseinate spreader was used. With proper agitation the emulsification and spread are fairly satisfactory, but when hard water is encountered, emulsification becomes impossible. Many places in northern California where hard water occurs, the calcium caseinate spreader cannot be safely recommended. This spreader has also been found to have a tendency to build up too heavy an oil film over comparatively long exposures, which makes its use dangerous under some conditions on such crops as apricot and peach.

Many types of spreaders have been studied for spread and oil-depositing properties in the laboratory, but none have as yet been found to equal the powdered blood albumin. Powdered blood albumin spreader is composed of 1 part Grade A powdered blood albumin of a definite high solubility and 3 parts of a suitable diatomaceous or finely ground earth. The spreader is used at the rate of 4 ounces to 100 gallons of spray. This past season it has been obtained in glassine-lined bags in two convenient sizes from manufacturers in Oakland and San Francisco. The 8-ounce package, sufficient for a 200-gallon tank sold at 11 cents a package, and the 12-ounce package, sufficient for a 300-gallon tank sold at 16 cents a package. It is inadvisable for anyone but a properly equipped manufacturer to prepare this spreader.

SPRAY-TANK AGITATION

Effective agitation is a requisite of primary importance in the use of most sprays. In using even the most stable commercial oil emulsions conditions are sometimes encountered where, owing to the breaking of the emulsion in hard water, or to the interruption of the spraying before the tank is emptied, the oil may become concentrated at the surface of

the water. Also in the use of insoluble insecticides, such as powdered lead arsenate and sulfur, sufficient agitation is important in order that a uniform concentration may be obtained. The agitation requirement prescribed for tank-mix spray assures that a uniform mixture will be had under all conditions.

In testing something over 200 sprayers in the field it was found that very few have adequate agitation, owing largely to the comparatively slow speed of the agitator shaft and to the propeller type of agitator

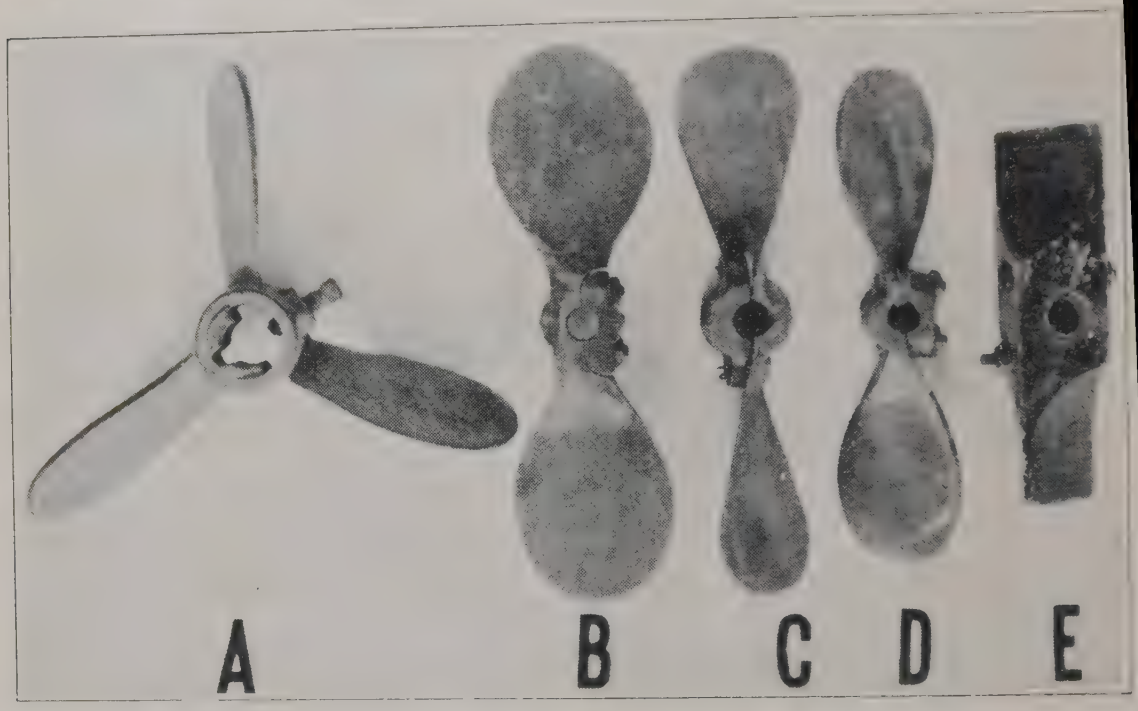


Fig. 2.—Different propeller types of agitators found in spray tanks in northern California. Agitators C, D, and E are not satisfactory with oil sprays.

(fig. 2). In Bulletin 527,[4] it has been shown that a uniform mixture may be obtained by increasing the speed of the shaft to 200 r.p.m. and using the proper kind and number of propeller-type agitators. The energy consumption is approximately ½ hp. This high-speed agitation is practicable with sprayers having 8-hp. motors, or over, and can be obtained by simply changing the ratio of the gears between the pump and agitator shaft.

In northern California a large percentage of the sprayers are equipped with tanks of 100, 200, or 300-gallon capacity, and with motors of 2½, 3, 4, 6, and 8 hp. A few sprayers have 300 and 400-gallon tanks and 12- or 15-hp. motors. The normal speed of the agitator shaft on the different makes of equipment varies widely. It is important to know this speed before making any changes in the agitators. This may be readily deter

[4] Smith, Ralph H. The tank-mixture method of using oil spray. California Agr. Exp. Sta. Bul. 527:1-84. Reprinted 1933.

mined by simply counting the revolutions of the sprocket at the end of the shaft outside the tank.

Investigations made in the orchards and in the laboratory of the Division of Agricultural Engineering at Davis have shown that adequate agitation cannot be obtained with the use of the propeller-type agitators (table 2), at speeds of from 100 to 120 r.p.m., and it is impracticable to employ the high-speed agitation on the low-powered sprayers. Accordingly, a new type flat square-end agitator (fig. 3) has been developed, which, in 100, 200, and 300-gallon tanks, will give uniform mixtures with an energy consumption of less than $\frac{1}{5}$ hp.

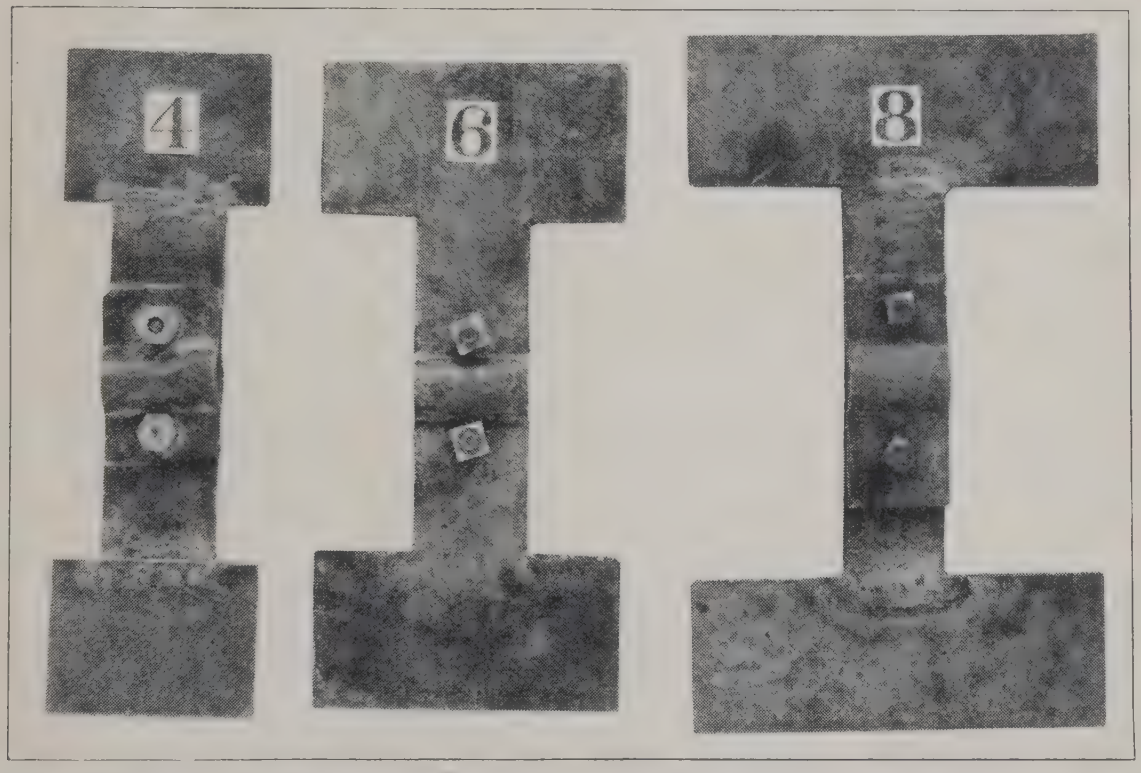


Fig. 3.—The new flat square-end agitators which should replace the propeller types of agitators in all spray tanks.

This new agitator is made of $\frac{3}{16}$-inch mild steel from 2-inch and 3-inch band material. The tips may be either welded or riveted on. The 13-inch length (fig. 4) is for tanks having the agitator shaft about 7 inches above the bottom of the tank and is to be run at speeds of from 95 to 110 r.p.m. Similarly patterned agitators 10 inches in length may be employed in tanks having the agitator shaft about $5\frac{1}{2}$ inches above the bottom of the tank at speeds of 140 to 150 r.p.m. Four of the agitators 10 inches in length, at a speed of 100 r.p.m., require approximately the same amount of energy as four of the 10-inch agitators running at a speed of 140 r.p.m.

The first three tests in table 2 are with propeller-type agitators, and

show the lack of uniformity in the mixture. The next three tests with the new flat, square-end agitators show uniform mixtures. The last three tests, in which two of the new flat, square-end agitators are used in combination with two propeller-type agitators, show that a speed of 100 to 110 r.p.m. is required. In all tests the tank was filled with water, and

TABLE 2

RESULTS OF AGITATOR TESTS, USING ONLY OIL AND WATER

Make	Spray-tank capacity, in gallons	Depth, in inches	Length, in inches	Agitators				Number of gallons in tank when samples were taken			
				Number	Type*	Size	Speed, in r.p.m.	300	200	100	10
								Per cent of oil in sample			
Propeller-type agitators											
Bean	200	28	52	2	A	large	98	.....	0.3	0.9	1.8
Hardie	200	33	44	2	B	large	150	.....	0.0	0.1	1.9
Bean	300	33	64	3	A	large	90	0.1	0.1	1.0	1.8
New flat, square-end agitators											
Bean	200	28	52	4	Flat	4-inch	90	.....	1.0	1.0	1.0
Hardie	200	33	44	4	Flat	4-inch	99	.....	1.0	1.0	1.0
Bean	300	33	64	4	Flat	8-inch	96	0.9	1.0	1.0	1.1
Combinations of new flat agitators and propeller types											
Hardie	200	33	44	2	A	large	100	.....	1.0	1.0	1.0
				2	Flat	4-inch					
Hardie	200	33	44	2	B	large	96	.....	0.7	1.0	1.2
				2	Flat	4-inch					
Hardie	200	33	44	2	B	large	110	.....	1.0	1.0	1.0
				2	Flat	4-inch					

* Type letters "A" and "B" refer to the propeller-type agitators shown in figure 2.

dyed kerosene was poured on the surface. The agitators were then started, and after running for 1 minute, the spray nozzles were opened and samples were taken at intervals during the emptying of the tank.

Since the dimensions of spray tanks are not uniform, caution should be used in obtaining sufficient agitation. Tanks differ particularly in their length and depth. It is advised that a test be made after the suggested number of agitators have been installed. The Farm Advisor or Agricultural Commissioner, will assist in this test.

In tanks having the agitator shaft 7 inches above the bottom and of 100 and 200-gallon capacity, with a speed on the agitator shaft of 95 to 110 r.p.m., four of the 13-inch agitators with 4-inch tips are recommended. In tanks of 300-gallon capacity, with a speed on the agitator shaft of 95 to 110 r.p.m., four of the 13-inch agitators with 8-inch tips are recommended. In 400-gallon capacity tanks, which usually have more than 8-hp. motors, it is better to resort to a higher speed on the

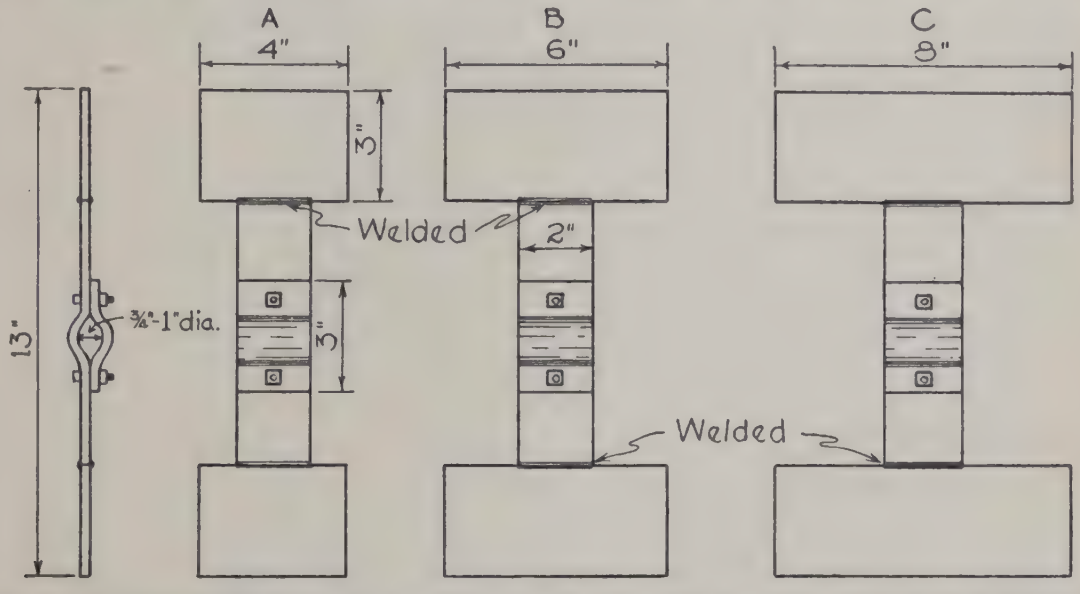


Fig. 4.—Patterns for the new, flat square-end agitators recommended in this bulletin.

agitator shaft, though four of the 8-inch tip agitators with a speed of 120 r.p.m., or above, are adequate.

In tanks having the agitator shaft about 5½ inches above the bottom and of 100 and 200-gallon capacity, with a speed on the agitator shaft of 140–150 r.p.m., four of the 10-inch agitators with 4-inch tips are required. In tanks of 300-gallon capacity four of the 8-inch tip agitators at the same speed are sufficient.

Two of the agitators should be placed as near the ends of the tank as possible and the other two spaced evenly between the end agitators. They may be set at right angles to each other or all four parallel.

It has also been found possible to combine the new flat agitators with certain of the larger propeller-type 3-bladed (fig. 2 *A*) and 2-bladed (fig. 2 *B*) agitators and obtain satisfactory results, as is shown in table 2. Two 3-bladed (fig. 2 *A*) agitators or two large 2-bladed (fig. 2 *B*) agitators and the two 13-inch new flat agitators with 4-inch tips at 110 r.p.m. gave a uniform mixture in 200-gallon tanks.

In certain underslung tanks which have the agitator shaft set at an angle the blade-type agitators present are usually adequate if running at a sufficient speed (140 r.p.m.). If not, however, a flat agitator can be designed to fit the different depths in the tank.

In most spray tanks there is a splash or filler box, with a screen which fits down into the opening of the tank. This usually extends 5 or 6 inches below the top of the tank and materially interferes with the obtaining of a uniform mixture when the tank is full, especially with the low-speed agitation. Also any cleats on the inside of the tank and cooling pipes check the agitation. A much more practical type of filler box may be constructed (fig. 5) which does not extend down into the tank and yet permits filling, testing the tank when full, and prevents splashing.

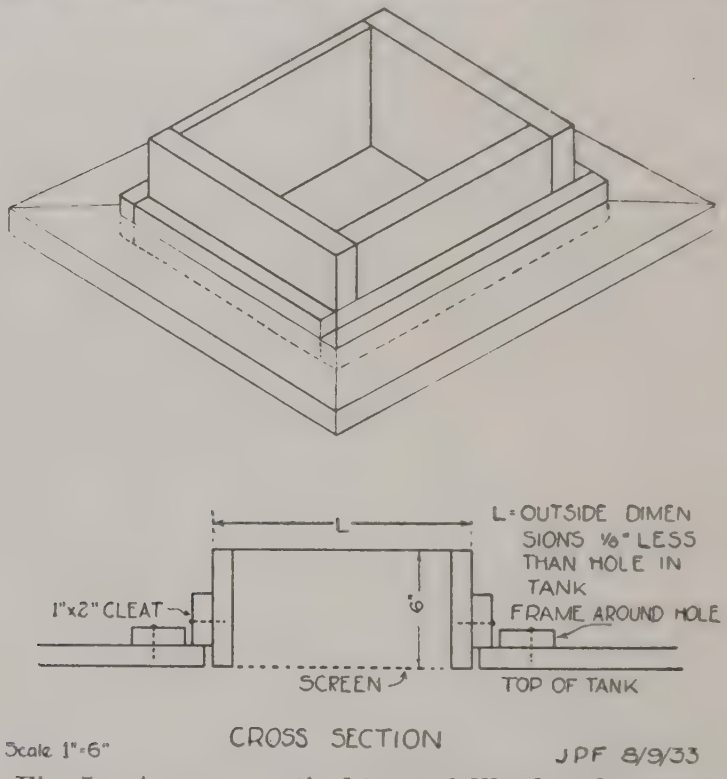


Fig. 5.—A more practical type of filler box for spray tanks, which does not interfere with agitation.

ORCHARD EXPERIMENTS IN THE SEASON OF 1931–32

During the winter spray season of 1931–32 over 4,000 gallons of dilute tank-mixture sprays were applied on several varieties of apples, Bartlett pears, and prunes on experimental plots in the control of San Jose scale and brown apricot scale. Spray oils of viscosities of 100, 120, 140, 160, and 200 seconds were employed at dosages of 3, 4, and 5 gallons per 100 gallons of dilute spray. The amount of spreader was varied from no spreader to 4, 6, 8, and 10 ounces per 100 gallons. As a comparative check some of the standard commercial oil emulsions were used at recommended dosages on each orchard sprayed. Counts of the San Jose scale were made at harvest time on approximately 1,000 to 3,000 apples per plot. Counts were made of brown apricot scale six weeks after the applications. Some of the data obtained are given in tables 3 and 4.

The data presented in table 3 indicate that the most effective control

TABLE 3

CONTROL OF SAN JOSE SCALE ON APPLE, SEASON OF 1931–32
(Spray applications made January 26 and February 26)

Material used	Oil		Spreader,* ounces per 100 gal.	Number of fruit counted	Per cent of fruit infested
	Dosage, in gal. per 100 gal. spray	Viscosity in seconds			
Tank mixture	4	100	0	1,511	1.3
			4	2,043	1.3
			6	3,280	6.8
			8	2,368	2.6
		120	4	1,563	1.3
			6	997	3.0
			8	1,389	5.0
		140	4	1,515	2.6
		160	8	1,557	4.5
		200	8	1,578	3.1
Commercial oil emulsion	5	110	0	1,393	3.0
Lime-sulfur	12	.....	8	1,333	2.6

* Blood albumin spreader is used in all cases except for lime-sulfur; calcium caseinate is used for the latter.

TABLE 4

CONTROL OF BROWN APRICOT SCALE ON PRUNE, SEASON OF 1931–32
(Spray applications made January 26 and February 26)

Material used	Oil		Blood albumin spreader, ounces per 100 gal.	Number scale counted	Per cent living scale
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds			
Tank mixture	3	100	6	1,052	2.8
			8	1,114	3.5
			10	1,116	5.2
		120	0	1,002	1.8
			6	1,112	2.0
			8	1,115	5.2
		140	6	1,114	3.5
Commercial oil emulsion	4	105	0	1,070	12.0

of the San Jose scale was obtained with the oils of 100 and 120 seconds viscosity and with 4 ounces of blood albumin spreader. Where no spreader was used the coverage was unsatisfactory. No difference was noted in the blooming time of the apples or pears on any of the spray plots where oils of different viscosities had been used.

In the control of brown apricot scale on prune, the best results were obtained with the lower dosage of spreader and with oils of 100 and 120 seconds viscosity. With late applications, the oils of 140 seconds viscosity and above delayed the bloom of prunes fully 10 to 14 days. January sprays are preferable to sprays applied late in February.

ORCHARD EXPERIMENTS IN THE SEASON OF 1932–33

During the spray season, 1932–33 over 7,500 gallons of dilute spray were applied experimentally on apricots, prunes, apples, and pears. Dosages for San Jose scale, brown apricot scale, fruit tree leaf roller eggs, and brown mite eggs were determined. Combination sprays of bordeaux mixture and the tank-mixture spray were applied to apricots in the "pink bud" stage, for control of brown rot and fruit tree leaf roller. The stimulation effect of different oils applied at monthly intervals on prunes was studied. The experiments were conducted in ten widely separated orchards of the coastal area, and in each orchard one or more standard commercial oil emulsions were used for comparison. Oils of three grades and viscosities from 70 to 140 seconds were used.

Scale counts were made about eight weeks after the applications, by counting all scale on 5 twigs—12 to 15 inches long—taken from each of 20 trees in each spray plot. Tables 5 to 11 give some of the data obtained.

RESULTS OF 1932–33 ORCHARD EXPERIMENTS

In the control of San Jose scale it has been well demonstrated that where the bark is not rough and the scale not encrusted a dosage of 3 gallons of Tank Mix Grade A oil and 4 ounces of blood albumin spreader per 100 gallons of dilute spray is sufficient.

The brown apricot scale on prunes is comparatively easy to kill until it begins to develop wax. In the early season, this scale on prunes usually can be killed with a comparatively low dosage, while late in February it becomes more difficult. On apricot, growth is usually faster than on prune, and a higher dosage is required. Where bordeaux mixture is combined with oil sprays on apricots and used as late as the "pink bud" stage, the scale is not only more difficult to kill, but the effectiveness of the oil is reduced, and the oil dosage must be increased.

The standard recommendation for the spraying of fruit tree leaf roller eggs has been 7 gallons of commercial oil emulsion per 100 gallons of dilute spray. Experiments in 1932–33 have amply shown that on prune and apricot satisfactory control can be obtained by the tank-mix method with a dosage of 4 gallons of oil and 4 ounces of blood albumin spreader per 100 gallons of dilute spray. The practicability of combining bordeaux mixture with the oil emulsion to be applied in the "pink bud" stage on apricots has been demonstrated.

TABLE 5

SAN JOSE SCALE CONTROL ON APPLE, SEASON OF 1932–33
(Spray applications made March 1, 1933)

Material used	Oil		Blood albumin spreader, ounces per 100 gal.	Number scale counted	Per cent living scale
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds			
Tank mixture	4	110	4	204	0.0
	3	110	4	191	0.0
	2	110	4	131	0.8
Commercial oil emulsion B	4	105	0	266	0.4
Tank mixture	4	110	4	256	0.0
	4	70	4	230	0.0
Commercial oil emulsion A	4	105	0	366	0.0

TABLE 6

CONTROL OF BROWN APRICOT SCALE ON PRUNE, SEASON OF 1932–33
(Spray applications made February 10, 11, 1933)

Material used	Oil		Blood albumin spreader, ounces per 100 gal.	Number scale counted	Per cent living scale
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds			
Tank mixture	3	110	4	2,576	0.4
	2	110	4	2,644	1.3
	1	110	4	1,251	1.0
Commercial oil emulsion A*	4	105	0	2,044	0.4
	3	105	0	1,581	0.5
	2	105	0	1,444	0.9
Commercial oil emulsion B†	4	110	0	1,726	0.6
	3	110	0	1,239	1.2

* Commercial oil emulsion A is classed as one with relatively high oil deposit.

† Commercial oil emulsion B is one with relatively low oil deposit.

TABLE 7

CONTROL OF BROWN APRICOT SCALE ON APRICOT, SEASON OF 1932–33
(Spray applications made February 8, 1933)

Material used	Oil		Blood albumin spreader, ounces per 100 gal.	Number scale counted	Per cent living scale
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds			
Tank mixture	3	100	4	1,039	0.1
	2½	120	4	1,340	3.2
	3	70	4	852	0.5
Commercial oil emulsion	4	105	4	906	0.8

TABLE 8

CONTROL OF BROWN APRICOT SCALE ON APRICOT WHEN COMBINED SPRAY* IS USED, SEASON OF 1932–33

(Spray applications made February 27, 1933)

Material used	Oil		Bordeaux mixture	Spreader,† ounces per 100 gal.	Number scale counted	Per cent living scale
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds				
Combined spray (tank mixture and bordeaux mixture)	4	110	4–4–50	4	328	1.0
	3	110	2–2–50	4	286	4.5
	3	110	5–5–50	4	290	24.8
Bordeaux mixture	....	.....	5–5–50	8	326	97.1

* Bordeaux mixture is used for control of brown rot on apricot.

† Blood albumin spreader is used in all cases except for bordeaux mixture; calcium caseinate is used for the latter.

TABLE 9

SPRAYING OF FRUIT TREE LEAF ROLLER EGG MASSES ON APRICOT, SEASON OF 1932–33

(Spray applications made February 21–23, 1933)

Material used	Oil		Blood albumin spreader, ounces per 100 gal.	Number eggs counted	Per cent hatched
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds			
Tank mixture	4	100	4	1,314	0.7
	5	110	4	992	0.9
	5	57	4	700	0.5
Commercial oil emulsion	7	105	0	704	0.2

TABLE 10

SPRAYING OF FRUIT TREE LEAF ROLLER EGG MASSES ON BLENHEIM APRICOT WHEN COMBINED SPRAY* IS USED, SEASON OF 1932–33

(Spray applications made February 25, 1933, in "pink bud" stage)

Material used	Oil		Bordeaux mixture	Spreader,† ounces per 100 gal.	Number eggs counted	Per cent hatched
	Dosage, in gal. per 100 gal. spray	Viscosity, in seconds				
Combined spray (tank mixture and bordeaux mixture)	5	100	2–2–50	4	1,934	0.6
	4	100	4–4–50	4	1,807	0.7
	3	100	5–5–50	4	2,026	1.4
Bordeaux mixture	....	.....	5–5–50	8	1,501	97.1

* Bordeaux mixture is used for control of brown rot on apricot.

† Blood albumin spreader is used in all cases except for bordeaux mixture; in the latter case calcium caseinate is used.

TABLE 11

EFFECT OF FOUR DIFFERENT DORMANT OIL SPRAYS ON THE CONDITION OF BLOOM AT VARIOUS DATES OF OBSERVATION
(Dosage rate = 3 gallons oil per 100 of spray)

Oil	Date of application	Condition of bloom				
		March 12	March 19	March 22	March 28	April 4
Brown Neutral oil	Jan. 13	Green bud	10 per cent white bud	White bud, some open	⅓ full bloom	Full bloom
	Feb. 9	Some green bud	Green bud	White bud, none open	¼ full bloom	Full bloom
	Mar. 9	Some green bud	Green bud	Green bud	*	50 per cent full bloom
Tank Mix, Grade B, 70 seconds viscosity	Jan. 13	Green bud	20 per cent white bud	White bud, some open	⅔ full bloom	Past full bloom
	Feb. 9	Green bud	Green bud, few white	White bud, some open	¼ full bloom	Nearly full bloom
	Mar. 9	Some green bud	Green bud	Green bud	*	80 per cent full bloom
Tank Mix, Grade B, 100 seconds viscosity	Jan. 13	Green bud	10 per cent white bud	White bud, some open	⅔ full bloom	Past full bloom
	Feb. 9	Green bud	Green bud, few white	White bud, few open	½ full bloom	Full bloom
	Mar. 9	Some green bud	Green bud	Green bud	*	50 per cent full bloom
Tank Mix, Grade A, 100 seconds viscosity	Jan. 13	Green bud	5 per cent white bud	White bud, very few open	⅓ full bloom	Full bloom
	Feb. 9	Some green bud	Green bud	White bud, none open	¼ full bloom	Full bloom
	Mar. 9	Some green bud	Green bud	Green bud	*	50 per cent full bloom
Check unsprayed	.....	Some green bud	Green bud	Green bud	White bud	80 per cent full bloom

* No observations made.

The study of stimulation effect of different oils applied at different times during the dormant period has shown that the greatest stimulation apparently occurs when applications are made early in January. The stimulation is more apparent at the time of the unfolding of the bud than at full-bloom time. The greatest stimulation was noted with an oil of 70 seconds viscosity and about 67 per cent unsulfonated residue. Bud stimulation, though used by some growers to prevent thrips attack and to increase chances of pollination, may or may not be advisable. This depends upon frost conditions at bloom time and thrips emergence.

DOSAGE RECOMMENDATIONS

From the above experiments and other field work it is apparent that the following recommendations may safely be made for the use of the tank-mixture method in dormant spray applications on deciduous fruit trees.

San Jose Scale.—In infestations where the bark is relatively smooth and the scale not incrusted, 3 gallons of Tank Mix Grade A oil and 4 ounces of powdered blood albumin spreader per 100 gallons of dilute spray is sufficient. The addition of 1½ or 2 pounds of caustic soda per 100 gallons of dilute spray may be made where the moss condition on the trees to be sprayed warrants its use.

Brown Apricot Scale.—A dosage of 2 gallons of Tank Mix Grade A oil plus 4 ounces of powdered blood albumin spreader per 100 gallons of dilute spray on prunes is recommended early in the season where the scale is not particularly advanced in development. Later in the season a 3-gallon dosage may be necessary. On apricots the scale usually develops faster and a 3-gallon dosage per 100 is recommended. Where bordeaux mixture is used in combination with the oil spray, a dosage of not less than 4 gallons of oil per 100 gallons of dilute spray should be used on apricots.

Fruit Tree Leaf Roller Egg Masses.—A dosage of 4 gallons of the Tank Mix A Grade oil per 100 gallons of dilute spray is recommended for the fruit tree leaf roller egg masses in the full dormant period. Where bordeaux mixture is to be combined in this spray the dosage should be 5 gallons of oil per 100 gallons of dilute spray.

Brown Mite Eggs.—Eggs of this mite are usually destroyed in any spray program for control of scale. Even 2 gallons of oil per 100 gallons of dilute spray gave perfect control on prunes sprayed while dormant.

SUMMARY

The tank-mixture method offers to the deciduous fruit growers a practical, economical means of obtaining a dormant spray for deciduous fruit trees.[5] The saving in cost of material is approximately one-half, and the coverage and oil-depositing properties of this spray are better than any thus far tested.

Proper agitation in the spray tank can readily be obtained by installing a sufficient number of the new flat, square-end agitators.

Over 5,000,000 gallons of dilute spray made by the tank-mixture method were applied by fruit growers to the orchards in six counties in northern California during the season of 1933. No injury has been recorded, and the control has been most satisfactory.

[5] The tank-mixture method may also be employed in the application of foliage or summer type sprays in the control of thrips, leafhopper, and codling moth in combination with nicotine, and for red spider as a straight oil spray. In these sprays a lower viscosity and higher unsulfonated residue oil is used. Experiments on the effects of these sprays are being completed.

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THRESHER AND OTHER MECHANICAL INJURY TO SEED BEANS OF THE LIMA TYPE

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THRESHER AND OTHER MECHANICAL INJURY TO SEED BEANS OF THE LIMA TYPE[1]

ROY BAINER[2] AND H. A. BORTHWICK[3]

INTRODUCTION

CALIFORNIA PRODUCES ANNUALLY several million pounds of both large and small lima bean seed. Much of this seed goes to eastern states, where it is used to produce either a market garden crop, in the case of the Fordhook variety, or both a market garden and a canning crop, in the case of the Henderson Bush variety.

During recent years much difficulty has been experienced, particularly in the East, in securing good stands of lima beans because of poor germination of the seed. Investigations[4, 5, 6] have shown that the cause is mechanical injury during threshing or handling. Growers and seedsmen, aware of this fact, have asked that the problem be attacked experimentally.

The following report is based primarily on results with the Fordhook and several small lima varieties. Although other types, such as certain snap beans and commercial dry shell beans, are subject to injury, limas appear to be most difficult to thresh without damaging the seed. If satisfactory methods of threshing them can be devised, the other beans can probably be handled similarly.

DESCRIPTION OF THRESHER INJURY

Growers have long recognized that some damage exists in almost all lots of machine-threshed beans. Generally, however, they have not understood that besides the visible damage there may be an even larger percentage of internal damage that cannot be detected until germination. The visible injury is in the form of split beans and cracked seed coats. This, though affecting several per cent of the crop under some

[1] Received for publication June 18, 1934.

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[4] Whitney, W. A. Mutilated seed—a contributing factor in defective stands of lima beans. (Abstract) Phytopathology 20(1):134–135. 1930.

[5] Harter, L. L. Thresher injury a cause of baldhead in beans. Jour. Agr. Research 40:371–384. illus. 1930.

[6] Borthwick, H. A. Thresher injury in baby lima beans. Jour. Agr. Research 44:503–510. illus. 1932.

threshing conditions, is less serious, from the seedsman's viewpoint, than the internal damage, because the obviously injured seeds can be recognized and removed when the beans are sorted at the warehouse.

The more serious type of thresher damage is that in which only the internal seed structure is broken. As seeds thus injured appear per-

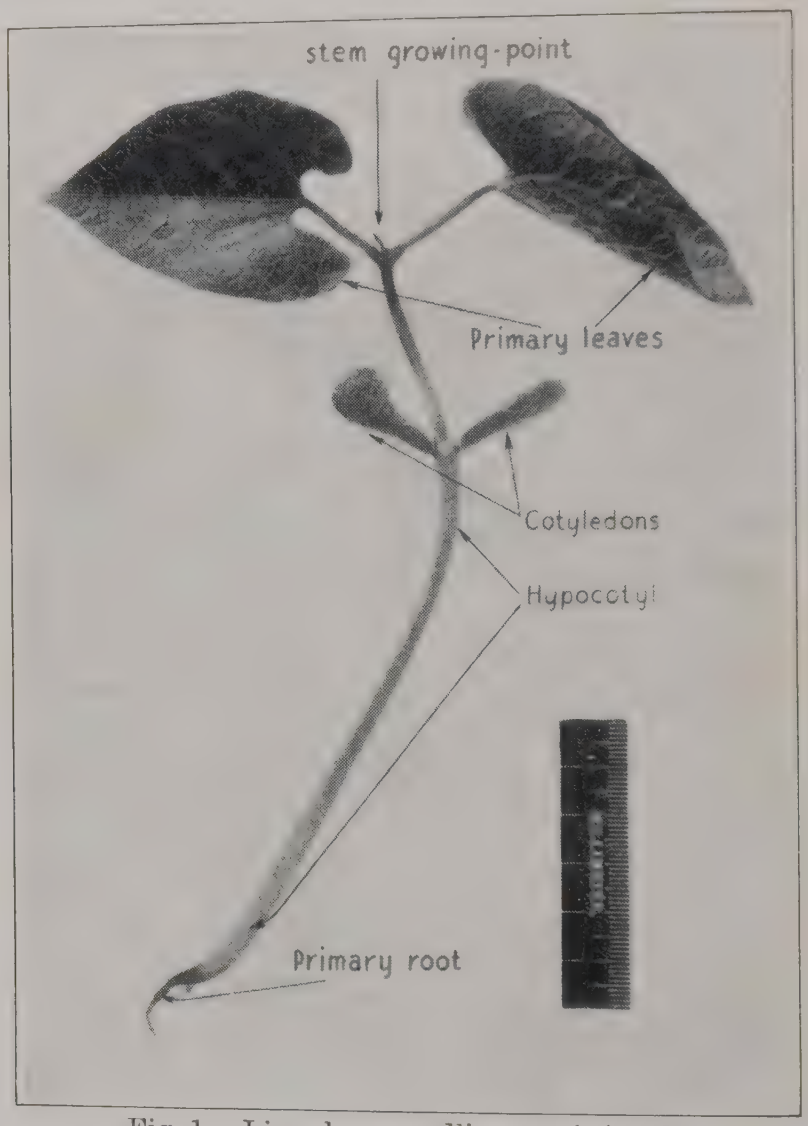


Fig. 1.—Lima bean seedling—uninjured.

fectly normal, the evidence is not found until germination. Thus, the defective seeds cannot be picked out even when known to be present in fairly large percentages.

A bean seed consists of a small dormant bean plant surrounded by a very thin seed coat. During germination this dormant plant resumes growth, bursts the seed coat, and develops into a bean seedling consisting of the primary root, the hypocotyl, two cotyledons, the stem growing-point, and the first true leaves (fig. 1). Since all of these structures are present in the bean seed before it germinates, it is obvious that they may be damaged during threshing or cleaning processes.



Fig. 2.—Various types of injuries in bean seedlings of the lima type. *A*, Baldhead; *B*, snake-head; *C*, baldhead seedling several weeks old; *D*, primary root missing; *E*, break close to cotyledons, causing them to remain below the ground.

Beans having internal injuries produce seedlings in which certain parts are either missing or defective. Often a seed may be so shattered internally that it fails to germinate at all. When planted in soil, such seeds rot without producing a seedling. If they are germinated on moist cloth or paper toweling, however, it is manifest as soon as they swell

that they have been internally shattered. One should remember tha such seeds are indistinguishable from uninjured ones before they ar placed on the germinator.

Other kinds of injury are numerous. Two widely recognized are th so-called baldhead and snake-head types. In the former the stem grow ing point and the first true leaves are missing; in the latter the tw cotyledons have been detached (figs. 2 *A* and *B*). Such seedlings seldo produce a crop of any importance. The growth made by a baldhea specimen after several weeks in the greenhouse is shown in figure 2 *C*

In still another kind of injury, the root and sometimes the lower par of the stem have been lost (fig. 2 *D*). In these cases development i greatly delayed because adventitious roots must be produced before th seedling can come up. Often the break is so close beneath the cotyledon that insufficient stem remains to raise them above ground in the manne characteristic of beans (fig. 2 *E*). The cotyledons then remain belo ground, and the plumule alone elongates.

Not uncommonly seedlings have large scars on their stems or roots indicating that certain injuries have healed during germination. Al though these usually grow into average-sized plants, their early develop ment is retarded; and probably, under some conditions of germinatio in the field, they may more readily fall victims to fungus diseases.

Besides the injuries described, seedlings with single cotyledons ar commonly found. Sometimes scars around the point of attachment sho that the cotyledons have been partly broken loose but have healed dur ing germination. In such cases the store of reserve food is not given u to the developing seedling so rapidly as by normal cotyledons; and th result is a retarded growth that may be directly charged to thresher o other mechanical damage.

EXPERIMENTAL PROCEDURE

Description of Experimental Threshing Equipment.—A cylinder an concave unit built for a commercial bean thresher was obtained. Th diameter of the cylinder, measured between tips of the teeth, was 2 inches. Teeth in the concave and cylinder bars were spaced 3 $^{15}/_{16}$ inches and the clearance between adjacent cylinder and concave teeth was $^{5}/_{8}$ inch. Teeth faced with tool steel were used throughout.

The cylinder and concave units were mounted in a special wood fram (fig. 3) so constructed that the beans were discharged from the cylinde directly into a removable box (fig. 4), in which a false bottom made o screen was placed about 2 inches above the floor so that the thresh beans could be easily separated from the straw and unthreshed pods This separation was made with a fork or by hand rather than with

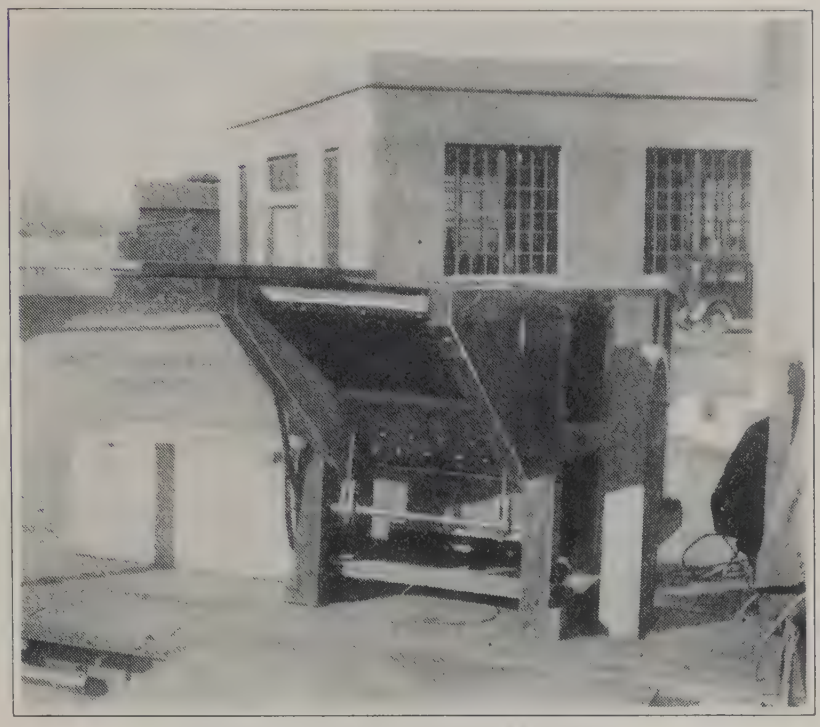


Fig. 3.—Experimental thresher.

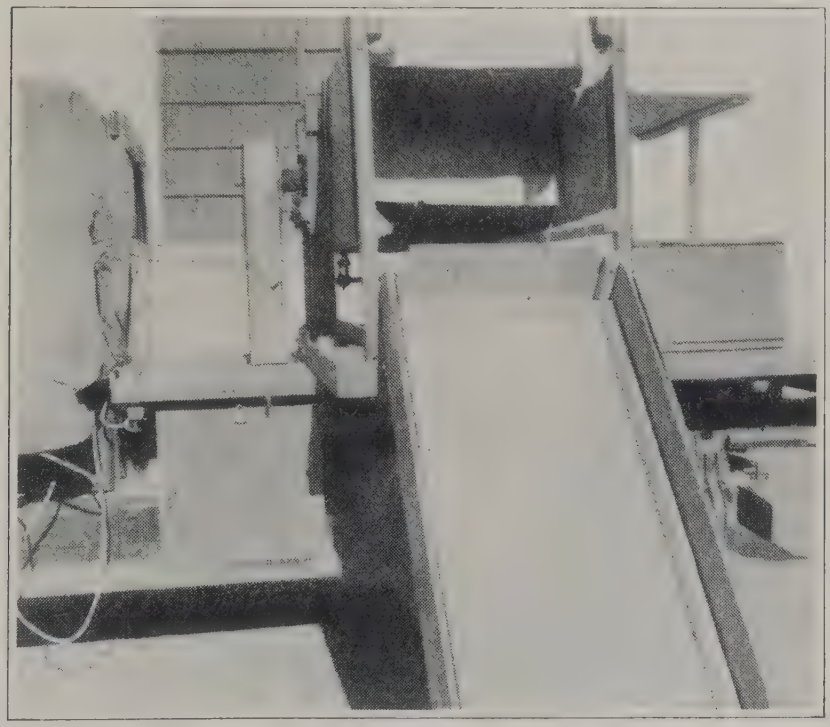


Fig. 4.—Removable container with false bottom.

special shaker, to avoid possible injury to the beans by parts of the machine other than the cylinder. A feeding table about 4 feet square was so constructed that it could be easily attached to the side of the machine. Provision was made for easy removal of the concave bars and for changing the position of the concave unit. End play of the cylinder was prevented by using set collars on both sides of each cylinder-shaft bearing.

This experimental thresher was mounted on the bed of a truck an was belt-driven from a power take-off on the truck engine, the speed which was controlled by a screw adjustment on the carburetor. Wit this equipment it was possible to operate over a wide range of spee without changing pulleys and to maintain any given velocity with high degree of precision.

Peripheral Speed, a Function of the Cylinder Diameter.—Inasmuc as two cylinders in the same threshing machine may have differen

TABLE 1

THE RELATION BETWEEN PERIPHERAL AND ROTATIONAL SPEED FOR CYLINDERS OF VARIOUS DIAMETERS

Peripheral velocity of cylinder, feet per minute	Diameter of cylinder in inches (tooth tip to tooth tip)						
	18	19	20	21	22	23	24
	Cylinder speed, revolutions per minute						
700	148	140	133	127	121	116	111
800	169	161	152	145	139	133	127
900	190	181	172	163	156	149	143
1,000	211	201	191	182	174	166	160
1,100	233	221	210	200	191	183	175
1,200	254	241	229	218	208	199	191
1,300	275	261	248	236	226	216	207
1,400	296	281	267	244	243	232	223
1,500	317	301	286	273	261	249	239
1,600	338	321	305	291	278	266	255

diameters, obviously if they are rotating at the same number of revolu tions per minute the tips of their teeth will be traveling at differen velocities. The cylinder of the greater diameter will therefore impart greater impact to a bean than will the smaller cylinder. Rotationa speed must be converted into linear velocity at the tips of the cylinde teeth (peripheral speed) so that the speeds of cylinders of differen diameters may be compared. To do this the circumference of the cylin der at the tip of the teeth must be determined in feet and multiplie by the revolutions per minute. This gives the peripheral speed in fee per minute. For a 21-inch cylinder rotating at 200 r.p.m. the calcula tions are as follows:

$$\text{Peripheral speed} = \frac{21}{12} \times 3.1416 \times 200 = 1{,}100 \text{ feet per minute.}$$

Table 1 has been prepared to show the relation between peripher and rotational speed for cylinders of various diameters.

Most of the threshing tests were made at peripheral speeds of betwee 770 and 1,560 feet per minute. The lower speed limit was established

a point below which a commercial machine cannot well be operated. The upper limit was determined by the visible damage produced in the beans. Whenever the product was obviously badly damaged, no further increase in speed was made.

Experimental Threshing Practice.—When the cylinder had reached the desired speed, as determined by a direct-reading speed indicator, enough beans to yield 15 to 20 pounds of threshed seed were placed on the feeder table and were fed into the cylinder as rapidly and evenly as its speed would permit. The box containing this material, which had been through the cylinder once, was removed; and the straw and the unthreshed pods were transferred to a canvas sheet. The threshed beans remaining in the box were then cleaned by a fan and weighed. A sample of 2 or 3 pounds, obtained with a Boerner sampler, was retained for further laboratory analysis. Next the straw and the unthreshed pods were run through the cylinder again at the same speed, and the beans threshed during this run were cleaned and sampled. In most cases each lot of beans was run through the cylinder three times at the same speed. Any remaining unthreshed beans were then either shelled by hand or run through again at a much higher speed. After every run, therefore, data were available as to the percentage of beans threshed out each time through the cylinder, and samples were saved for further study. Tests resembling the one described above were made at each of five different speeds, and the entire series was repeated as many as five times.

After being threshed, the samples were brought into the laboratory and divided to about 350 grams in the case of the baby lima type and to about 1,000 grams in the case of the Fordhooks. After all foreign matter had been removed by hand picking, the samples were accurately weighed. The broken beans (those with part of the seed actually missing) and the cracked beans (those with visible skin cracks) were then measured separately and removed. From the remainder, germination samples of 400 beans were selected, all visibly undamaged, having acceptable size from a seedman's viewpoint, and apparently not diseased.

Method of Conducting Germination Trials.—All germination tests were made at 80° F. The beans were germinated between wet paper towels on wire trays—a method preferred to soil tests chiefly because it permitted daily observation of the samples and more accurate investigation of the failure of certain seeds. Each sample remained in the germinator for a week or ten days.

In some samples a few seeds failed to absorb water when placed on the germinator. This condition, known as hardshell, was always eliminated by slightly scratching the seed coat, whereupon every live seed immediately absorbed water and germinated. When large enough to

display all their parts, the seedlings were removed from the germinat and divided into damaged and undamaged lots. The damaged seedlin were further subdivided into six lots, namely: (1) internally shattere (2) two cotyledons missing, (3) plumule missing, (4) hypocotyl radicle missing, (5) axis cracked, and (6) one cotyledon missing.

RESULTS OF THRESHER TRIALS ON BABY LIMA BEANS

Tests on Hopi Baby Lima Beans.—Threshing tests were run in a fiel of lima beans of the variety Hopi 155 grown on the University Far at Davis, California. This variety is a baby lima type selected from th

TABLE 2

EFFECT OF CYLINDER SPEED ON THOROUGHNESS OF THRESHING AND ON PRODUCTIO OF VISIBLE AND INTERNAL DAMAGE TO BABY LIMA BEANS OF 9.1 PER CENT MOISTURE CONTENT

Cylinder speed, peripheral-feet per minute	Per cent threshed			Per cent damaged		
	Once through cylinder	Two times through cylinder	Three times through cylinder	Visible*	Internal†	Total‡
770	70.3	85.7	92.1	0.8	7.5	7.6
940	73.9	88.0	94.6	2.4	13.9	15.1
1,150	82.6	94.0	97.6	6.2	20.7	25.0
1,330	88.3	96.5	98.6	16.2	29.4	40.6
1,560	92.2	98.5	100.0	24.2	37.3	52.5

* Based on total amount of beans threshed.
† Based on beans remaining after removal of visibly injured portion.
‡ Based on total amount of beans threshed.

native limas grown by the Hopi Indian tribe in Arizona. The moistur content was 9.1 per cent—very near the lower limit of the range en countered in practice but not uncommon in lima beans grown in th central valley of California. Five different cylinder speeds between th limits of 770 and 1,560 feet per minute were used, and the tests at eac speed were replicated five times. The percentages of visible and interna damage, and of the completeness of threshing, were recorded fo each lot.

Visible damage to these beans occurred at even the lowest speed use For an average of five replications it ranged from a fraction of 1 pe cent at the lowest speed to nearly 25 per cent at the highest speed (fig. and table 2). Internal damage at the lowest speed amounted to approx mately 7 per cent of the beans that were left after the visibly injure ones had been removed, and this increased to more than 37 per cent a the highest speed. The values in table 2 given in the column showin per cent of total damage are obtained by converting the percentages

internal damage to the same basis as those of visible damage and adding the two. It then becomes obvious that cylinder speed has a direct influence; the damage is appreciable at even the lowest speed and becomes enormous at the highest speeds. The quality of work done by the threshing machine is usually judged in part by the visible damage produced. This method, though acceptable for commercial beans, may be very unsatisfactory for seed beans because of the internal and, therefore, invisible damage produced in the seed.

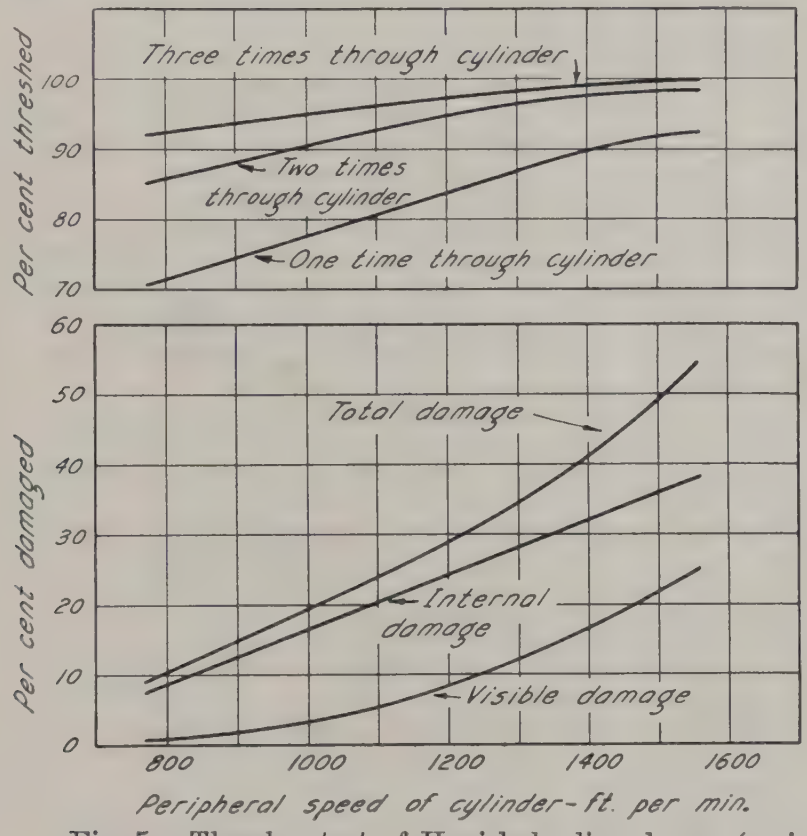


Fig. 5.—Thresher test of Hopi baby lima beans (moisture content 9.1 per cent), showing the percentage damaged as well as the percentage threshed for one, two, and three times through the cylinder at different peripheral speeds.

Thoroughness of threshing, which directly depends upon cylinder speed, is another criterion by which the quality of the work is judged. Besides threshing the seed without injury, the machine must remove all or nearly all the beans from the straw. Table 2 and figure 5 show the total percentage of the crop threshed out at the end of one, two, and three runs through the cylinder. According to these data, a machine containing three cylinders all operating at the same peripheral speed would thresh out over 90 per cent of these beans in one run through the machine at the lowest speed indicated. To do an equally thorough job with two cylinders would require a peripheral cylinder speed of nearly 1,150 feet per minute; and a single-cylinder machine would have

to operate at 1,560 feet per minute to equal the effectiveness of th cylinders running at 770 feet. These three machines operating at t speeds mentioned above would have done about 7.6, 25.0, and 52.5 p cent damage respectively (table 2). Apparently, therefore, a thr

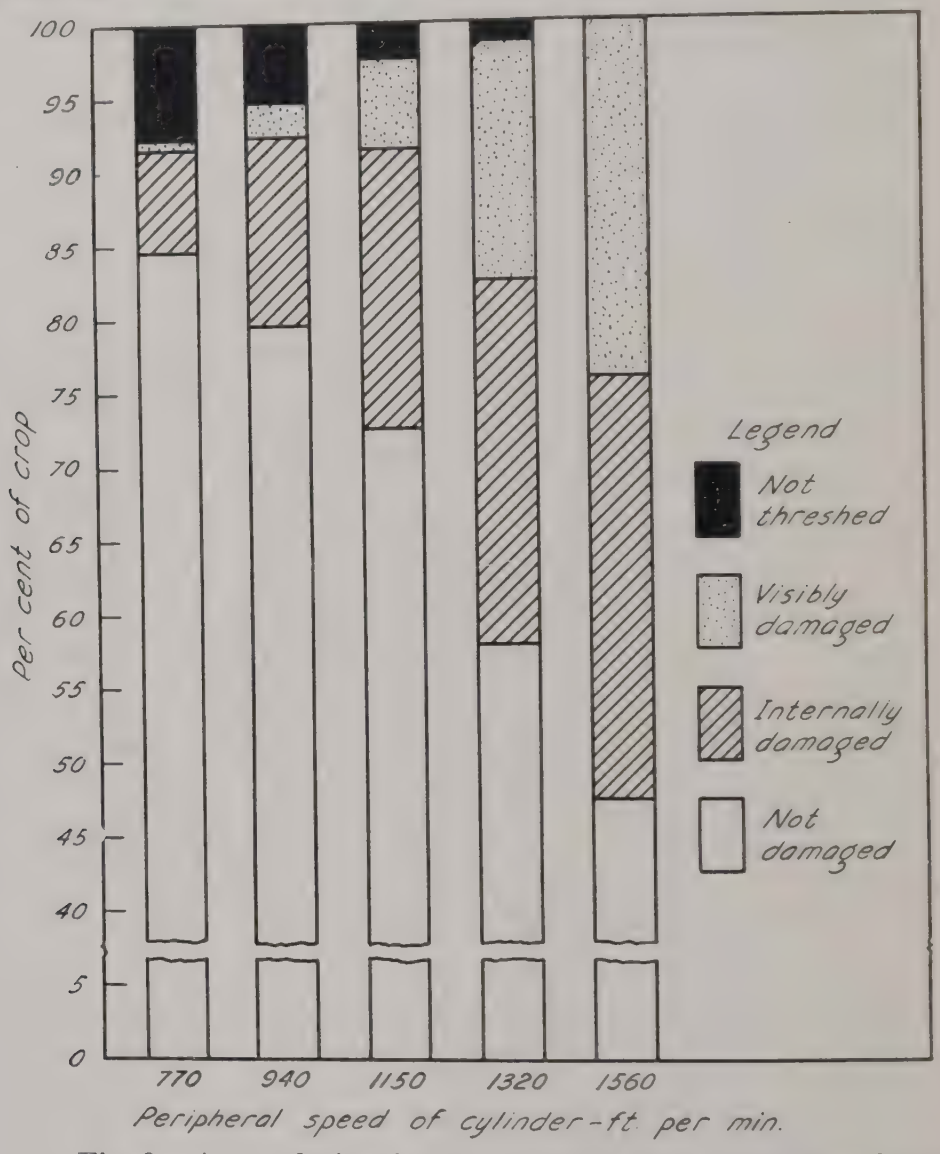


Fig. 6.—An analysis of data obtained from Hopi lima beans (moisture content 9.1 per cent), threshed at five different cylinder speeds.

cylinder machine is superior to one of fewer cylinders for threshing s beans with minimum damage.

The question has been raised as to which of the cylinders in a mach produces the greatest percentage of damage to the beans it thres provided they are all running at the same peripheral speed. Accord to threshing tests with both baby and Fordhook lima beans, there is significant difference.

Loss Caused by Damage Compared with Loss Resulting from Inc plete Threshing.—In the preceding paragraphs the effects of cylin

speed on visible injury, internal injury, and percentage of beans threshed have been considered separately. Although a greater percentage is threshed as the speed increases, a greater amount of damage is done. Whether or not the increased output compensates for the additional damage must now be determined. For this purpose the data discussed above have been summarized and are presented graphically in figure 6.

These data (fig. 6) may be considered from several points of view. Obviously, for example, the commercial thresherman is interested in operating his machine as fast as possible without too much visible damage, because at higher speeds he threshes out a higher percentage of the beans and finishes the work much faster.

The grower is usually paid for the seed remaining after all visibly defective beans have been removed by hand-pickers. He is therefore interested in cylinder speeds of 1,150 feet per minute or less because his output of salable beans decreases very abruptly at speeds above this point (fig. 6). Between 770 and 1,150 feet per minute he nets about the same quantity of salable beans. The grower will observe that at a speed of 1,150 feet per minute he has to pay threshing charges on 97 per cent of his crop and sells 91; the 6 per cent remaining are visibly damaged and have little commercial value. At the lowest speed, on the other hand, he sells almost all the beans threshed, has no additional threshing and hauling costs to pay, and has practically no defective beans for sale. His attempts, therefore, to secure a more complete job of threshing by speeding up the machine have not resulted in the production of more salable seed.

The seedsman would very much prefer that the beans be threshed at the slowest speed for at least two reasons. First, he has practically no cost of hand-picking because only a fraction of 1 per cent damage occurs at this speed. Second, the beans threshed at the lowest speed contain the smallest percentage of internal damage. From this point of view, the thresherman should receive a bonus, equal to the difference in cost of hand-picking, if he would run slowly.

The man who uses the beans as seed is, of course, concerned only with the internal damage; all visibly damaged beans have presumably been removed before he gets them. He therefore insists that the product contain the maximum possible percentage of undamaged seed. The beans threshed at the lowest speed most nearly meet this requirement.

According to the data obtained from the threshing tests described above, a peg-tooth cylinder does not thresh baby lima beans satisfactorily for seed purposes at any speed if their moisture content is very low. Further data concerning the influence of moisture on threshing

injury will be presented elsewhere in this bulletin. Under the condi tions of the experiment, 7.6 per cent total damage occurred at a cylinde speed of 770 feet per minute. Although this is more damage than shoul be tolerated, the cylinder speed is too slow for practical operation of machine.

Tests on Wilbur Lima Beans.—A second series of threshing tests wa run later in the season in a field of baby limas of the Wilbur variety These beans are a long-vined type and contained about 16.4 per cent o

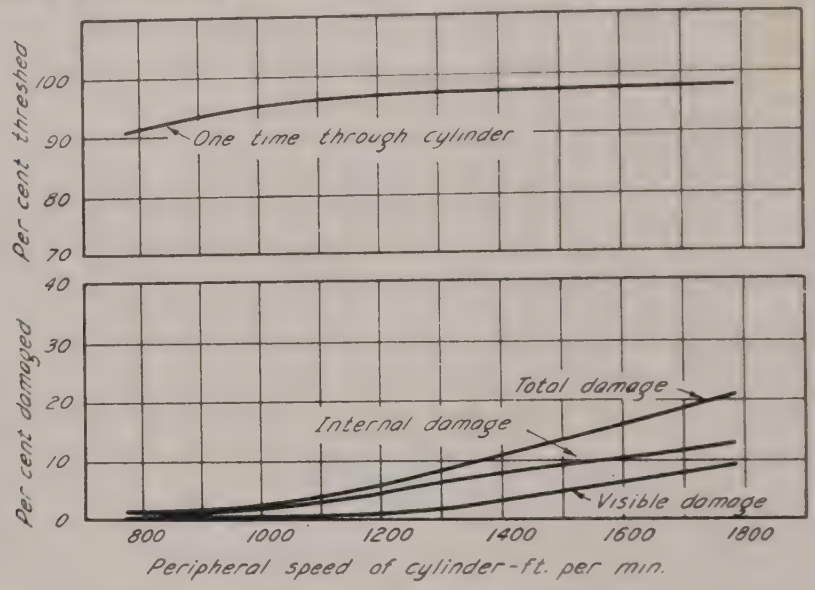


Fig. 7.—Threshing tests of Wilbur baby lima beans (moisture content 16.4 per cent), showing the relation of the amount of damage and the percentage threshed to various cylinder speeds.

moisture. Whereas the pods were dry and opened easily, the vines were green and tough, and tended to wrap around the cylinder at the lower speeds. Some of the beans, accordingly, though fed into the machine only once, may actually have gone through the cylinder several times.

The total damage varied from 1.0 to 21.0 per cent for cylinder speeds of 770 and 1,785 feet per minute, respectively, (figs. 7 and 8). From the results of these tests, two points are at once apparent. First, the injury was much less than with the Hopis discussed above, probably because of the moisture content, which was about as high as is commonly found in baby lima beans threshed for seed. Second, although the total injury was low, the effect of increasing speed was very similar to that found in the Hopis. Visible injury, for example, did not occur below a speed of 1,150 feet per minute; and at the highest speed (1,785 feet per minute) it amounted to only 9 per cent. Internal damage, though occurring at all speeds, increased along with the speed until it amounted to 13 per cent of the recleaned beans at the highest speed. It exceeded visible damage at all speeds, as shown in the previous tests. At even the lowest speed

over 90 per cent of the seed was threshed when put through the machine once. Increasing the speed, therefore, did not greatly increase the percentage threshed.

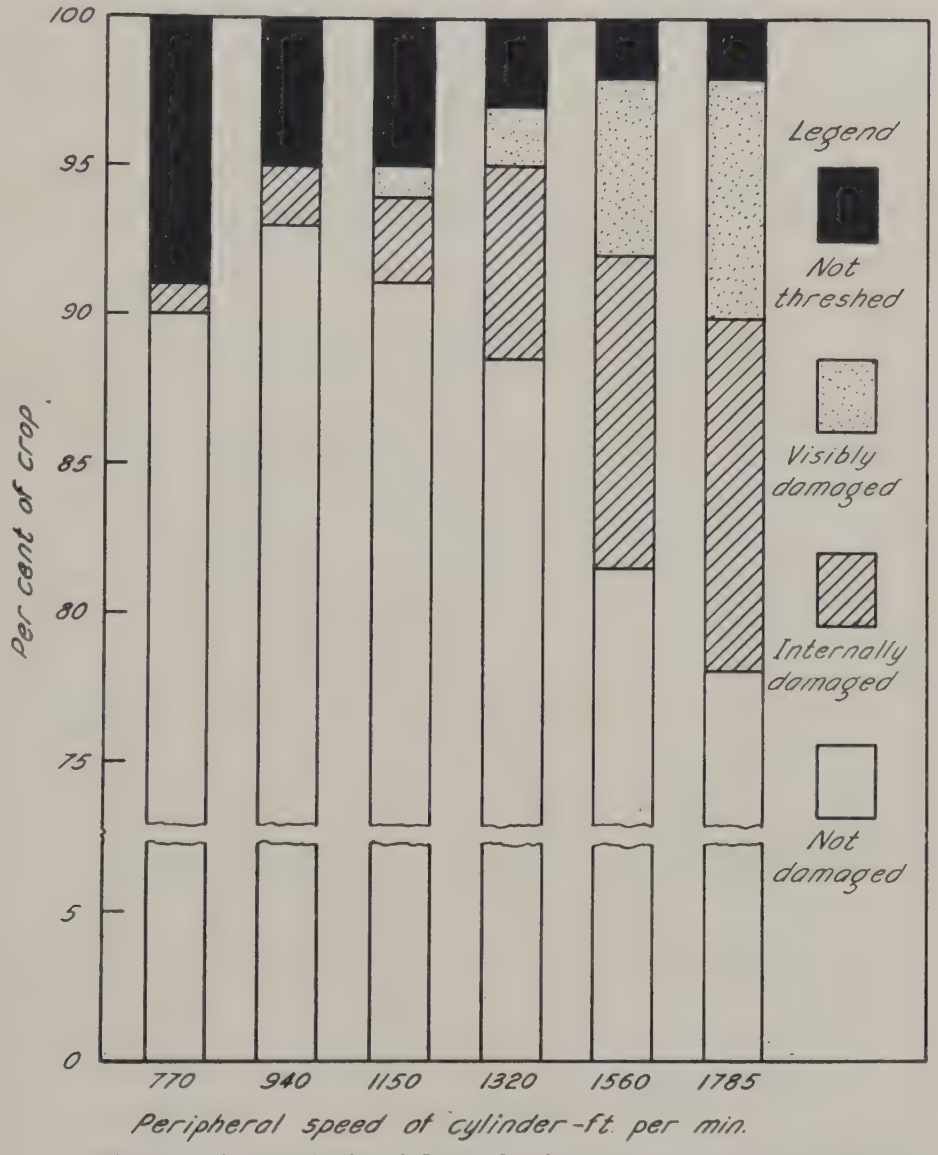


Fig. 8.—An analysis of data obtained from Wilbur baby lima beans (moisture content 16.4 per cent), threshed at six different cylinder speeds.

According to these tests (fig. 8), a speed of 770 feet per minute is too slow. At 940 feet per minute, a higher percentage of the crop can be threshed without visible damage or material increase of internal damage. The differences in internal damage at 770 and 940 feet per minute are probably not significant. In the speed range of 940 to 1,320 there is little difference in the percentage of salable beans produced; but there is a difference in the amounts of visible and internal injury—a fact indicating the desirability of maintaining the speed at the lower limit of this range. At higher speeds the per cent of salable beans decreases, and both internal and visible damage increase very rapidly.

The two series of tests described above were conducted at the extremes of moisture conditions for bean threshing. Great differences in the total damage were found in the two fields, the one with the lower moisture displaying most severe injury. In both cases the data show very clearly that high cylinder speed directly causes defective seed and that for a product of highest quality the machine should be operated as slowly as practicable.

Although a peg-tooth cylinder is unsatisfactory for threshing seed beans of low moisture content, it can be used safely when the moisture content is high, provided the speed is kept low.

THRESHING STUDIES ON FORDHOOK LIMA BEANS

The Fordhook is a large lima bean grown for seed along the coast, principally in Ventura and Santa Barbara counties. All threshing studies upon it were conducted in fields near Oxnard, Ventura County. On the morning that the work was started a light rain began to fall, which continued throughout the day and evening. In the night approximately ½ inch fell.

One three-cylinder commercial machine continued to thresh in spite of the light rain. The straw was run through the machine twice to insure the threshing of all beans. It was felt advisable to begin the thresher studies under these weather conditions and to continue as long as practicable. During this initial trial the cylinder was operated at 1,320 feet per minute (240 r.p.m.). The beans contained 16.4 per cent moisture. The vines were damp, and the pods tough. Although very little water had apparently been taken up, the beans had become somewhat soft and spongy.

The straw was run through the cylinder six times—the equivalent of two trips through a three-cylinder machine. After each run, the threshed beans were removed from the straw; those remaining after the sixth time through were shelled by hand. Approximately 75.3 per cent were threshed the first time through the cylinder. On successive runs 13.4, 5.9, 2.7, 1.4, and 0.8 per cent, respectively, were threshed. The beans not threshed amounted to 0.5 per cent. The total threshed in the first three trips through the cylinder was 94.6 per cent. Only 4.9 per cent were removed in the next three times through the cylinder. The total damage to this lot amounted to 17.4 per cent, of which 14.2 per cent was visible and 3.2 per cent was internal.

On the second day good drying weather prevailed. Although the beans were too damp for commercial threshing, the experimental work was continued. The moisture content was now 18.8 per cent.

Threshing was carried on at five cylinder speeds, ranging from 770 to

1,560 feet per minute. As shown by the data (fig. 9), the total damage was 3.5 per cent at the lowest speed, increasing to 13.5 per cent at the highest speed. The amount threshed for three times through the cylinder varied from 66.5 to 96.5 per cent.

The threshing trials were continued on the third day. Weather conditions continued favorable. The bean straw had dried sufficiently for the

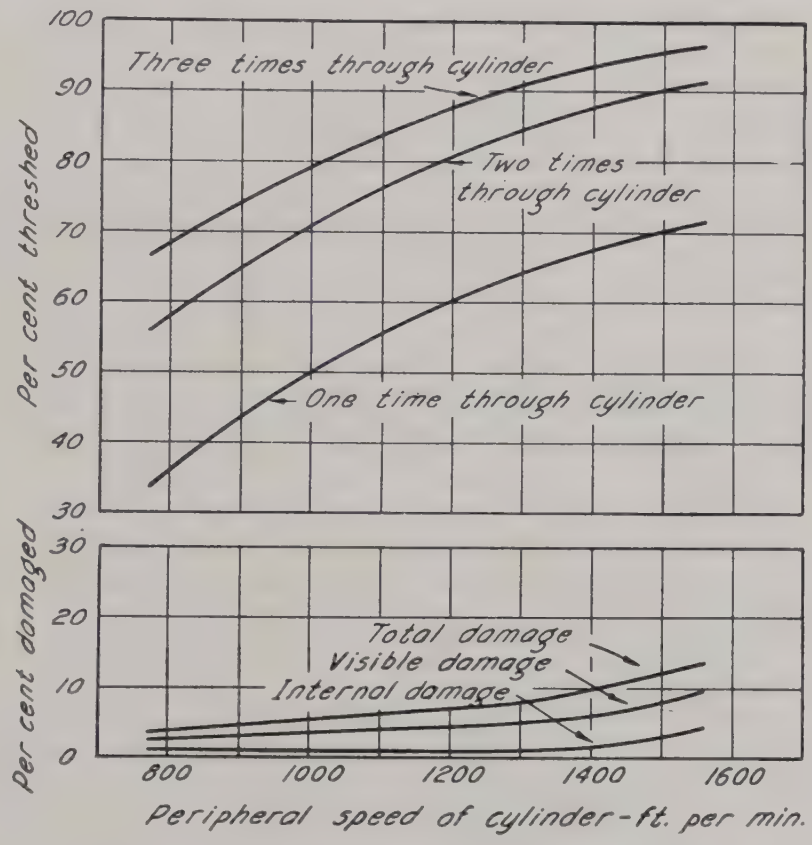


Fig. 9.—Threshing tests in Fordhook beans (moisture content 18.8 per cent). Total damage varied from 3.5 to 13.5 per cent for the different cylinder speeds. The percentage threshed for three times through the cylinder varied from 66.5 to 96.5 for the same range in speeds.

commercial machines to start, and the moisture content had dropped to 17.3 per cent. Beans were threshed at four cylinder speeds, varying from 770 to 1,320 feet per minute. As visible injury was quite evident at the latter speed, a higher one was not used.

The per cent of thresh, for three times through the cylinder, varied from 82.5 per cent at 770 feet per minute to 99.0 per cent at 1,320 feet. The total damage amounted to 2.0 per cent and 15.0 per cent, respectively, for the two speeds (fig. 10).

By the fourth day the moisture content in the beans had dropped to 15.9 per cent. The speeds used varied from 850 to 1,150 feet per minute. Threshing was discontinued with a top speed of 1,150 feet because of

the large amount of visible damage appearing. Higher speeds would have damaged the beans without adding much value to the data.

For a cylinder speed of 850 feet per minute the total damage was 3.0 per cent, and the amount threshed for three times through the cylinder was 91.5 per cent; while at 1,150 feet per minute (fig. 11) the damage was 15.0 per cent and the thresh 97.5 per cent.

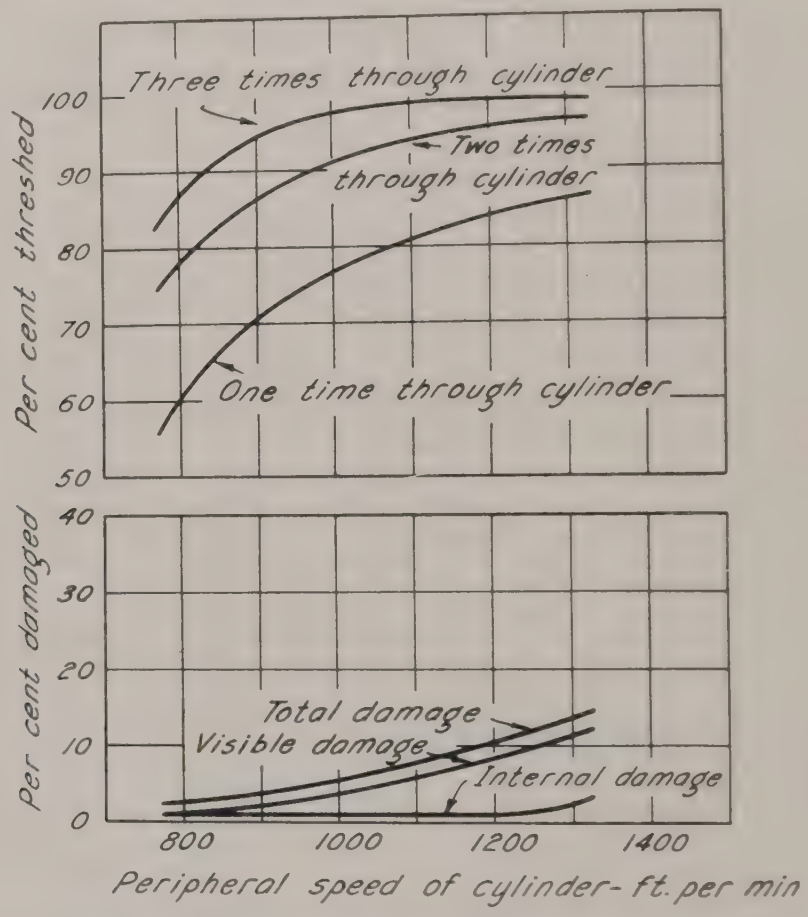


Fig. 10.—Threshing tests of Fordhook beans (moisture content 17.3 per cent). Damage varied from 2.0 to 15.0 per cent for cylinder speeds ranging from 770 to 1,320 feet per minute. The percentage threshed for three times through the cylinder varied from 82.5 to 99.0 for the same range in speeds.

Apparently the moisture content of the beans directly influences their susceptibility to damage: the higher it is, the less the damage, provided the threshing is done at a constant speed. The relation between the speeds required to produce a given amount of damage to beans of different moisture contents is shown in figure 12. For example, a total damage of 15 per cent was produced in beans containing 18.8 per cent moisture by threshing at a speed of 1,600 feet per minute; in another sample, containing 17.3 per cent moisture, at 1,330 feet per minute; and in a third, containing 15.9 per cent moisture, at only 1,150 feet per minute. At the lower extremity of the curves, considerable overlapping

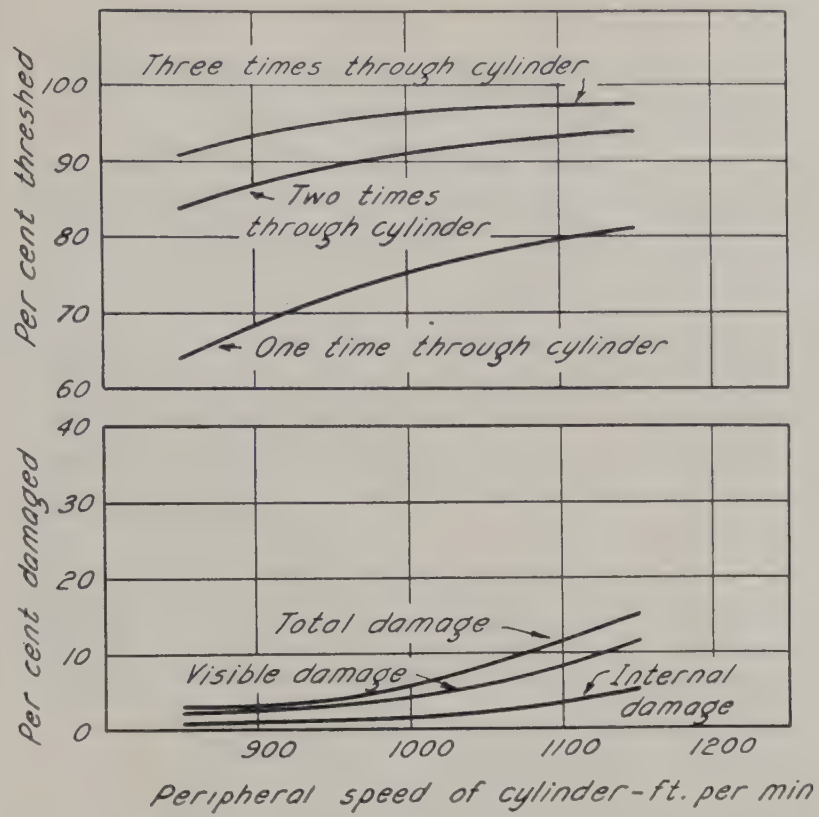


Fig. 11.—Threshing tests of Fordhook beans (moisture content 15.9 per cent). At a cylinder speed of 850 feet per minute the total damage was 3.0 per cent, and the amount threshed for three times through the cylinder was 91.5 per cent; while for a speed of 1,150 feet per minute the damage was 15.0 per cent and the thresh 97.5 per cent.

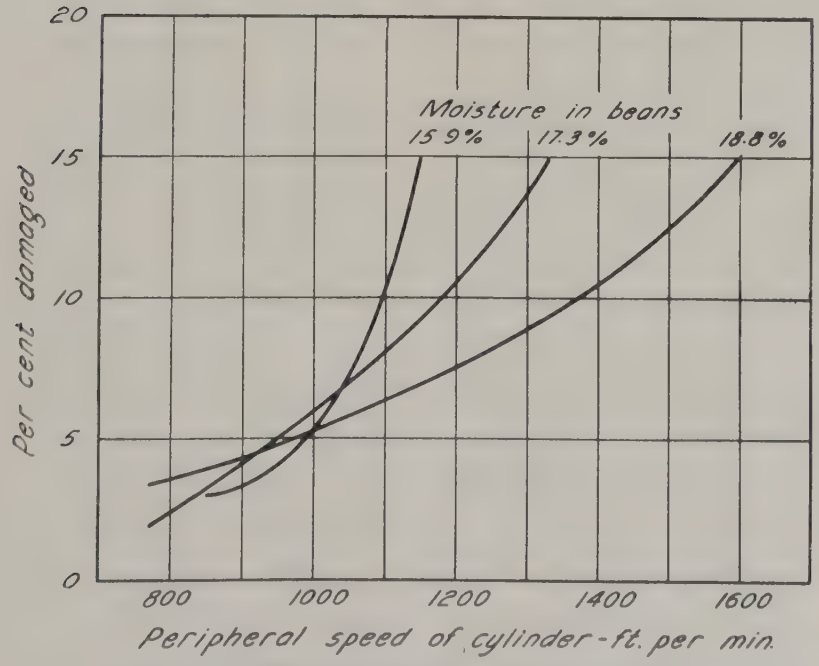


Fig. 12.—The cylinder speeds required to produce 15.0 per cent damage in Fordhook beans containing 15.9, 17.3, and 18.8 per cent moisture were 1,150, 1,330, and 1,600 feet per minute respectively.

occurs. The difference in damage for speeds of 1,000 feet per minute or less is not significant. Had the speeds in each case, regardless of moisture content, been kept at 1,000 feet per minute or less, the damage would have been approximately 5 per cent. Data presented in a later section of this bulletin indicate that beans of low moisture content are more susceptible to thresher damage than beans of higher moisture content.

In a special run with Fordhooks containing 17.3 per cent moisture, the cylinder speed was increased each time the straw was run through. At 770 feet per minute, the initial speed, 62.1 per cent of the beans were threshed, of which only 1.8 per cent were damaged. At 940 feet per minute, the speed used for the second run, 27.9 per cent were threshed, and 3.9 per cent were damaged. At 1,150 feet per minute, in the third run, the thresh was 6.7 per cent, of which 8.0 per cent were damaged. The remaining 3.3 per cent were shelled by hand. Total damage, recalculated on a prorated basis, amounted to 2.7 per cent of the crop. This example shows the necessity of operating at least the first cylinder at a minimum speed. Since over half the beans are threshed at this point, a large number will show little damage.

Cylinder speeds of 770, 940, and 1,150 feet per minute may be duplicated in a commercial machine having three cylinders, 21, 21, and 18 inches in diameter (tooth tip to tooth tip), respectively, from front to rear, by driving the respective cylinders at 140, 170, and 245 r.p.m. Under unfavorable conditions, a speed of 140 r.p.m. on the first cylinder is often too slow; but frequently beans should be threshed at that rate in order to produce high-quality seed. Naturally the capacity of the machine will be materially reduced in slowing down the cylinders. The cleaning-table speed must, however, be maintained even though the cylinders are slowed down. This may be accomplished by changing the gear or pulley ratio between the cylinder and the table eccentric drive, thus maintaining the speed of separation even though the beans pass through the cylinder more slowly.

The peripheral speed at which successive cylinders operate should be gradually increased from the front of the machine to the rear. If the speed of the first cylinder is kept to a minimum, a high percentage of damage-free seed will be threshed. Then, as the straw moves back through the machine, the remaining beans will be removed by cylinders operating at successively higher speeds. Although greater injury will result from the higher speed, the total damage in these cylinders will be smaller because most of the crop is threshed in the first one. The purpose of the third cylinder is to clean up the straw. Since, at this point, usually only 5 to 10 per cent of the beans remain, a higher speed with resultant higher damage to a few beans must be tolerated in order to remove most of the beans.

The third cylinder of several commercial machines studied was 18 inches in diameter. In most cases its rotational speed equalled or exceeded that of either the first or second cylinders; but because of its smaller diameter the speed on the periphery was slower. In a three-cylinder machine, for example, having cylinders 21, 21, and 18 inches in diameter, the rotational speed was 180, 216, and 216 r.p.m., respectively. When the rotational speed is converted to peripheral velocity at the tip of the cylinder teeth, the speed becomes 990, 1,185, and 1,015 feet per minute. In this case the last cylinder might well have been run at 1,500 feet per minute, if necessary for removal of the beans, without materially increasing the total damage, because the percentage threshed by this cylinder is small.

MISCELLANEOUS FACTORS AFFECTING QUALITY OF THRESHING

Rate of Feeding the Threshing Machine.—Trials were run with a commercial stationary thresher to determine approximately how the rate of feeding the machine affects the total damage. These tests were run in two lots of Fordhook beans containing 17.3 and 14.6 per cent moisture. The damage found in samples obtained from light, ordinary, and heavy feeding amounted to 6.0, 4.7, and 3.6 per cent, respectively, for beans containing 17.3 per cent moisture; 11.4, 8.6, and 7.4, respectively, for beans containing 14.6 per cent moisture. Though the differences are probably not significant, there seems to be a definite trend—a finding which agrees with the common opinion of threshermen that light or irregular feeding should be avoided. The portable pick-up machine is much more subject to irregular feeding than the stationary rig, because of the time that the machine runs empty while turning at the end of the row.

These tests on the rate of feeding, incidentally, illustrate again the effect of moisture content. The damage in beans containing 14.6 per cent moisture is practically twice that for beans containing 17.3 per cent.

Effect of Misalignment of Cylinder and Concave Teeth upon Quality of Threshing.—The clearance between cylinder and adjacent concave teeth must be sufficient to permit the seed being threshed to pass through. It amounts to approximately $\frac{5}{8}$ inch for different makes of bean threshers used in California.

Cylinder and concave teeth are often bent sidewise by rocks entering the cylinders with the beans or because of heavy threshing conditions. Consequently, the space between the cylinder tooth and the adjacent concave tooth on one side may be greater than the space on the other side. As a result, beans caught between the two teeth having the nar-

row clearance may be broken, while a whole pod may pass through the larger clearance untouched.

Occasionally the set collars on the cylinder shaft work loose, allowing the cylinder to slip sidewise, changing all of the clearances between cylinder and concave teeth. The result is end play. Sometimes the collars are reset against the cylinder shaft bearings, making this misalignment permanent. A few commercial machines were found with such misaligned cylinders. In one two-cylinder machine, threshing Henderson Bush beans, the cylinder had slipped sufficiently to reduce the clearance between cylinder and concave teeth to ¼ inch on one side and to increase the clearance on the other side to ⅞ inch. A considerable number of the beans were not threshed, while the others showed a high percentage of visible damage but relatively little internal damage—the latter probably because of the comparatively low cylinder speed used (990 feet per minute).

Many threshermen believe that the most important single factor affecting quality of threshing is clearance between teeth (bent teeth). A few tests, therefore, were made in which as many as 40 per cent of the cylinder teeth were bent. The total damage done with the machine in this condition, illogical as it seems, did not differ significantly from that produced with the machine in proper adjustment. Although these tests were not numerous, the data apparently should have shown a trend if bent teeth were as important as previously assumed. Whether or not bent teeth contribute materially to the amount of damage, the operator should, of course, maintain uniform clearances between cylinder and concave teeth to insure thorough threshing. The factor of clearance between teeth is apparently less important than cylinder speed.

OTHER METHODS OF THRESHING

Disk Threshing.—One grower of Fordhooks was found threshing his beans with a single disk harrow set straight and drawn by a team of horses. A circular area in the field had been carefully leveled, and a layer of bean straw about 6 inches deep and 4 or 5 feet wide was spread in a large circle. This was driven over repeatedly, and the threshed beans were gradually worked to the center and the straw to the outside. The layer of material under the disk was kept several inches thick at all times to prevent damage to the beans. When the pile of threshed material in the center of the ring reached considerable size, threshing operations were transferred to an adjoining area while another crew cleaned and sacked the beans with a fanning mill. Upon analysis of the samples less than 1 per cent of visible damage was found, and the internal damage amounted to merely a trace. This method, although slow, gave

very good results with this operator and perhaps has some real merit, particularly for the small grower.

Roller Threshing.—Roller threshing of baby limas was once common and is still practiced to some extent. The beans are usually spread on large canvas sheets and are threshed with a large wooden roller drawn by horses. Although this method frequently gives good results, in some cases it produces considerable injury. In four lots of roller-threshed seed obtained from a seedsman, the damage ranged from 2.6 to 38.1 per cent. Since most of this presumably occurred during threshing, much care should be exercised even with the roller method.

EFFECT OF MOISTURE CONTENT OF BEANS ON THEIR SUSCEPTIBILITY TO INJURY CAUSED BY IMPACT

Data presented on preceding pages showed that beans of low moisture were damaged to a greater extent by a threshing machine operating at a given speed than were beans of high moisture content. Although moisture seems the most probable factor responsible, this point was not conclusively proved. It was necessary, therefore, to devise tests eliminating other possible factors and clearly showing the effect of moisture alone in this regard.

Experiments reported elsewhere[7] showed that injuries like those found in machine-threshed seed could be produced in the laboratory with beans that had been carefully hand-shelled. In this work the beans were placed on a table and snapped with a steel spring. When germinated, a large percentage produced damaged seedlings, whereas the hand-shelled seeds not subjected to this treatment showed no such seedlings.

Although this method gave satisfactory qualitative results, the speed of the spring could not be easily controlled and measured at the time of impact with the seed. Quantitative results were therefore out of the question, and other means of producing the impact had to be devised.

Since the intensity of a shock is determined by the speed of one object relative to another with which it collides, it matters little which one is moving. In the threshing machine the beans may be hit by a moving part, or they themselves may be moving and may be stopped by a stationary part of the machine. In either case they receive an impact. For these experiments it was convenient to make the bean the moving object and a steel block the stationary object. The beans were given their velocity by dropping them. During such a free fall they obey the law of falling bodies, which enables one to calculate their velocity at any given

[7] Borthwick, H. A. Thresher injury in baby lima beans. Jour. Agr. Research 44:503–510. 1932.

point. Air friction of course introduces an error; but this, in the range of distance used in these experiments, is negligible.

The equation covering the law of falling bodies is as follows:

$$V = \sqrt{2gh},$$

where,

V = velocity in feet per second.

h = height of fall in feet.

g = acceleration of gravity (32.2 feet per second per second). For determining the distance through which an object must fall to give it any desired velocity, this equation may be transformed to $h = \frac{V^2}{2g}$.

Calculations were made to determine the distances that beans must be dropped to give them velocities equal to those of the cylinder teeth when the various tests reported on preceding pages were carried out. These

TABLE 3

RELATION BETWEEN MOISTURE CONTENT OF WILBUR LIMA BEANS AND PERCENTAGE OF DAMAGE CAUSED BY IMPACTS OF DIFFERENT INTENSITY

Distance dropped, feet	Velocity attained, feet per minute	Moisture content			
		5.8 per cent	9.6 per cent	14.1 per cent	15.9 per cent
		Total damage, per cent of sample			
2.55	770	40.7	18.2	2.7	1.0
3.81	940	52.9	28.7	.....	0.4
4.50	1,020	58.7	40.7	6.7	.....
7.61	1,330	86.0	57.9	.....	4.3
10.50	1,560	94.2	76.7	23.6	8.4

showed, for instance, that at the end of 2.55, 7.61, and 10.50-foot falls, velocities of 770, 1,330, and 1,560 feet per minute, respectively, were attained. A 21-inch cylinder, accordingly, rotating at 285 r.p.m. gives a bean no greater impact than does a free fall of 10.5 feet.

Experiments were therefore made to determine the amounts of injury produced in beans of known moisture content by dropping them various distances. The samples used were hand-shelled limas of the Wilbur variety containing 15.9 per cent moisture when shelled. One series of tests was made at this moisture content while other series were run at lower moisture contents obtained by slow drying. The various moisture contents used and the distance that the beans were dropped, together with their speeds at the time of impact, are indicated in table 3 and presented as curves in figure 13. Although the velocities of the beans at the time of impact were kept within the range of cylinder tooth velocities

used in threshing, direct comparisons between these and the threshing experiments are obviously impossible. In these dropping tests each bean receives one impact, and the impacts are very nearly equal. In machine tests some beans may possibly receive no impact at all, while others may receive several unequal ones. Comparisons, therefore, are to be made only among these dropping tests themselves and should not be extended to the machine.

Table 3 and figure 13 show that for any given intensity of impact the damage varies inversely with the moisture content. Five different

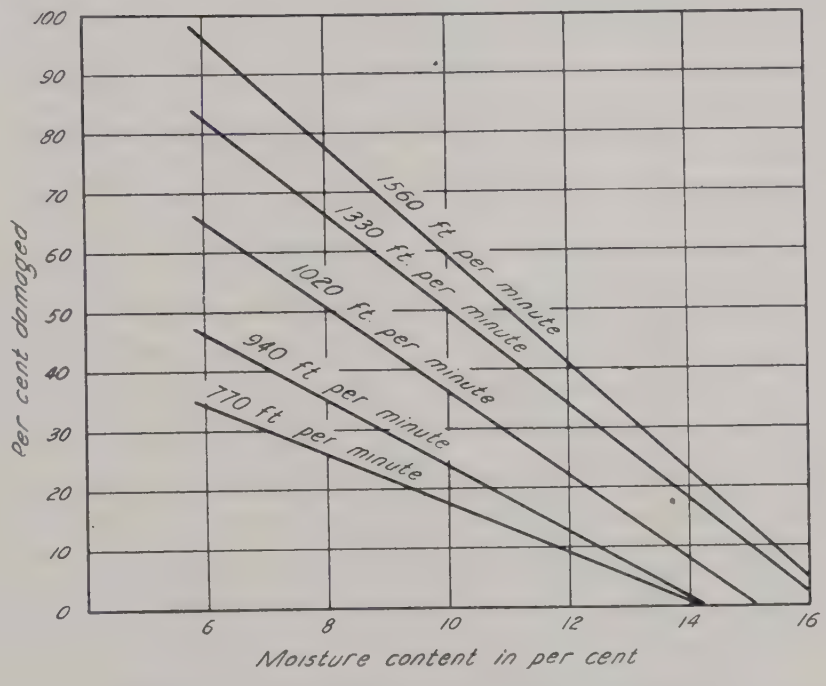


Fig. 13.—The relation between the moisture content of the beans and the percentage damaged. Velocities at the time of impact varied from 770 to 1,560 feet per minute.

impact intensities, as measured by the velocity of the bean at the moment of collision, were used; and this inverse relation between moisture content and damage held equally well in all cases. Similar experiments with the Fordhook, Hopi, and Henderson Bush varieties were carried out with similar results. Two lots of Fordhooks containing 11.1 and 15.9 per cent moisture, for instance, received 39.3 and 2.4 per cent total damage respectively from a fall of 2.5 feet. Three lots of Henderson Bush limas containing 10.4, 13.4, and 16.3 per cent moisture were injured 38.1, 12.2, and 1.7 per cent respectively by a fall of 10.5 feet.

The moisture content is thus established as fundamentally important in the threshing of seed beans. Although it cannot be controlled in the field, accurate knowledge of it is an important guide in determining how high a cylinder speed may be used with safety.

POSSIBLE SOURCES OF DAMAGE OTHER THAN THE THRESHING MACHINE

Growers and others have frequently maintained that the threshing machine is not the only source of damage to seed beans. Among several other places where they claim injury may occur, the chief is the seed-cleaning plant. The possible validity of this contention was not obvious until after the experiments reported in table 3. Since, for example, beans containing 9.6 per cent moisture may receive as much as 18 per cent damage in falling 2.5 feet, cleaning equipment obviously presents a definite hazard. The data of table 3 clearly showed the desirability of examining the more common types of equipment to determine whether or not they do subject the seed to impact of sufficient intensity to cause damage.

A survey, therefore, was made of the cleaning equipment of a number of California seed companies that handle lima bean seed in quantity. The object was to locate possible impacts and to determine their magnitude as nearly as possible.

Seed-cleaning plants are mainly of two types: one is several stories high; the other, one or two stories. In both, the beans are received in the bag and stored in the warehouse until cleaning time. In the case of the high warehouse, they are then elevated to the extreme top of the building in one operation and placed in temporary storage bins, whence gravity conveys them to the mills. There may be two or more mills, located on successive floors, and the beans go down from one to the other and finally to the hand-picking tables, where women remove split, cracked, or otherwise visibly defective seeds. The remaining beans then go to temporary storage bins below the tables, whence they are drawn off and sacked on the floor below. The bags are then piled in the warehouse until time for shipment.

In cleaning plants of the low type the beans are cleaned similarly except that all equipment is located on one or two floors. The seed, consequently, is elevated a short distance several times rather than a long distance once. These short elevations are accomplished by belt conveyors or, in some cases, by sacking the seed and elevating it in the bag.

The method of elevation varies in different plants. Sometimes freight elevators having a capacity of many bags per load are used, or chain elevators that carry the beans in bags. Still other plants use either large or small-type cup elevators. In one the buckets are large and move slowly; in the other they are small and move fast. The large buckets fill as they rise past a stream of falling beans and empty by tipping into a box at the top. The small buckets fill by dipping into a reservoir of beans

at the bottom; and, since they are moving fast, they empty by throwing the beans free of the elevator in going over the pulley at the top.

Some of these elevators may damage the seed, while others do not. There seems little opportunity for injury in those that handle sacks. The large-bucket bulk elevator should also be fairly safe. Although it is filled as the beans fall into it, they drop a very short distance; and since the speed of the bucket is not great, the combined speeds should not produce a very severe impact. When emptied out, the beans again receive a small drop; but this is also so short that little damage can result. The small-bucket elevator, however, is definitely open to suspicion. Its buckets travel so fast that they undoubtedly do some damage when they hit the beans in the reservoir at the bottom. In emptying, they throw their contents with considerable velocity, which is further increased by an amount determined by the fall. The speed of the beans at the time of impact is therefore rather high.

After leaving the elevator, the beans are delivered to temporary storage bins 15 or 20 feet deep. Instead of dropping directly to the bottom, they frequently roll down a series of slides from one side of the bin to the other. These slides are inclined at from 30° to 45° and in some cases are nearly 17 feet long. Upon reaching the bottom of each incline, the beans hit the wall before starting down the next one, receiving a rather severe impact that presents another possible point of damage.

Leaving these storage bins, the beans flow slowly through pipe conveyors to the machine below. Once these pipes are full, chances of injury are null. There is little opportunity for damage in the cleaner. Although the beans are shaken and slid about, they receive no free falls of any appreciable distance; and no other sources of impact were observed.

From the last cleaner the beans are taken through pipes to the hand-picking tables, where, of course, they receive no damage. As they leave these tables, however, they go down another inclined slide 3 to 6 feet long and hit the side of a small storage bin below the table. This impact may sometimes cause damage. No further impacts are received except those from filling the bags, which are presumably of little or no consequence.

Inasmuch as the seed-cleaning plants had finished the season's run before their possible importance in seed injury was understood, no experimental work could be done in them. Certain features of the warehouse that seemed to present the most probable sources of damage were, however, duplicated in the laboratory. On slides constructed, for example, at a 45° angle, hand-shelled baby lima beans were allowed to roll various distances before hitting a board at the bottom comparable to the side of the bin. Beans of 10.6 per cent moisture content, rolled down

this slide, showed total damages of 4.5, 8.6, and 15.3 per cent, respectively, for slide distances of 6.4, 10.4, and 15.0 feet. Tests of the same kind with Fordhook beans gave similar results.

These experiments show very clearly that much damage may be produced in beans in the warehouse, where they may go down such slides more than once. In one laboratory test the same lot was sent down a 45° slide 15 feet long three times in succession. The total damage was 42.8 per cent, representing an average accumulation of 14.2 per cent injury for each time over the slide. This figure agrees very well with the 15.3 per cent damage obtained by running a similar lot over the slide a single time. Since a slide of less than 7 feet caused 4.5 per cent damage, beans might receive some injury even after leaving the picking table.

In a comparison made, hand-shelled beans from the same source were dropped upon a steel block, upon a pine board, and into a bucket of beans. In the last case the beans already in the bucket were differentiated by staining. All lots fell 10.5 feet. Total damage resulting was 63 per cent for dropping upon steel, 21 per cent for dropping upon a pine board, and 9 per cent for dropping into beans. Evidently, therefore, beans are damaged significantly even by falling into other beans.

Damage was also found in baby lima beans run down a 30° slide. The amount was less, however, than with a steeper slide. For example, beans received about 16 per cent damage from a slide of 15 feet at a 45° angle and only 6 per cent from a slide of 21 feet at a 30° angle, yet each slide lowered the beans the same distance.

The laboratory experiments in imitation of warehouse conditions were performed with seed containing approximately 10 per cent moisture. Had the moisture content been higher, the damage would have been less. Under some moisture conditions the beans would probably have survived any of these treatments without serious damage; but 10 per cent is not an unusually low moisture content, particularly for baby limas grown in the interior valleys. If beans are handled with as little moisture as this, evidently extreme care must be taken.

Although many of the drops that beans receive in the warehouse are rather short and probably do little damage, some harm is nevertheless done; and since these small drops occur repeatedly, the total injury may be considerable.

A further point brought out by experiments involving the dropping of beans was that the damage resulting from impacts of low intensity is mostly internal. As the impacts become more severe, visible damage makes up a greater part of the total. Since many of the impacts in the warehouse are not severe, a large part of the harm done is probably internal.

It has also been found that internal injury makes up a greater portion of the total injury in beans of high moisture than in beans of low moisture. As the moisture increases, the amount of visible injury resulting from cleaning processes will decrease very quickly; and such damage as does accumulate will be largely overlooked because of its internal character.

The planter has also been suggested as a possible source of damage. Although it did not appear important in the case of seed beans, comparative tests were made with planters of both the plate and pick-up types. After samples of hand-shelled beans had been run through, the seeds were germinated. Although an occasional bean was cracked, no significant injury was found. If the planter is properly adjusted and operated it seems thus definitely eliminated as an important source of damage to seed beans.

SUMMARY

Many types of beans are damaged for seed purposes at the time of threshing, or later, during the milling and handling operation. The lima varieties appear to be the most difficult to thresh without injury. Damage may be either visible or internal. The latter is more serious because it cannot be detected until the seeds are germinated. Beans so injured produce mutilated seedlings in which parts are either missing or broken.

Peripheral velocity is a more satisfactory basis than speed of rotation for comparing the effects of cylinders having different diameters and operating at different speeds.

Cylinder speed and percentage of damage are directly related; the greater the speed, the greater the damage. Total damage to a lot of baby lima beans, containing 9.1 per cent moisture, varied from 7.6 to 52.5 per cent at threshing speeds of 770 to 1,560 feet per minute.

A lot of baby lima beans containing 16.4 per cent moisture showed 1.0 and 21.0 per cent damage, respectively, at cylinder speeds of 770 and 1,785 feet per minute.

High moisture content in the beans permits higher cylinder speeds to be used without an increase in the total damage.

The cylinder speeds required to produce 15.0 per cent total damage in Fordhook beans containing 15.9, 17.3, and 18.8 per cent moisture were 1,150, 1,330, and 1,600 feet per minute, respectively.

A thresher having only one cylinder is not suitable for seed beans, because the speed necessary for thoroughness is too high for the production of damage-free seed.

A low speed on the first cylinder of a two or three-cylinder machine usually insures the threshing of a high percentage of the crop with a

minimum of damage. If speed on successive cylinders is increased, the threshing can be completed without damaging a high percentage of the seed.

More damage apparently occurs during light feeding of the threshing machine than during ordinary or heavy feeding. For example, the total damage to Fordhook beans containing 14.6 per cent moisture amounted to 11.4, 8.6, and 7.4 per cent, respectively, for light, ordinary, and heavy feeding.

Fordhook beans carefully threshed with the ordinary disk harrow, set straight, showed only 1.2 per cent total damage.

The total damage to four lots of baby lima beans, threshed by rolling, varied from 2.6 to 38.1 per cent.

According to laboratory tests in which beans of various moisture contents were subjected to impacts of equal intensity by dropping them known distances, beans of high moisture receive less damage than beans of low moisture. The results agree with those obtained from threshing tests in the field.

Moisture content is of fundamental importance in the threshing of seed beans. Although uncontrollable, it is nevertheless an important guide in determining how high a cylinder speed may be used with safety.

The fast-moving cup-type elevators and the steep slides found in bean warehouses are the most likely points where damage to seed beans during handling may occur. Beans of 10.6 per cent moisture content, rolled down a 45° slide, showed total damage of approximately 4.5, 8.6, and 15.3 per cent respectively for slide distances of 6.4, 10.5, and 15.0 feet. Comparative tests showed that neither the plate nor the pick-up type of planter produces any appreciable amount of damage.

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BERKELEY, CALIFORNIA

CALIFORNIA COUNTY EXPENDITURES

J. K. GALBRAITH

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CALIFORNIA COUNTY EXPENDITURES[1, 2]

J. K. GALBRAITH[3]

FOREWORD

THIS STUDY is intended as a first step in the development of a research program by the Giannini Foundation of Agricultural Economics in problems of public finance in their relation to agriculture. The acuteness of the agricultural-tax situation in recent years has been apparent to all. Not so apparent have been the ways and means of ameliorating the situation in a reasonably permanent and equitable manner. Granting that changes in the public business, as it affects the California farmer and the citizens of the state in general, have been shown to be necessary in recent years, there is every need for the fullest understanding of this public business. False panaceas and illusory suggestions for reform flourish where there is an inadequate knowledge of the actual, if often disconcerting, facts. Disappointment and consequent delay of really substantial progress usually follows such fruitless change.

Furthermore, government and the provision of government services constitute by far the most important coöperative undertakings of the people of California. This creates a need for widespread understanding of governmental activity which has been recognized since the time of the earliest democratic institutions.

PUBLIC FINANCE AND PUBLIC EXPENDITURE

In periods of depression, particularly when there is a rapid and considerable decline in the general levels of prices, public attention soon becomes drawn towards those charges which have failed to partake of the downward trend. Whether large or small, such charges become relatively more important than before as they come to absorb a larger percentage of the diminishing money incomes of individuals, households, and business organizations.

Interest charges and certain types of taxes have been the outstanding examples of these fixed charges in recent depression years. Unchanging dollar levels of indebtedness, with a constant level of charges for interest thereon, have borne heavily on all types of business. In both industry,

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through the Reconstruction Finance Corporation, and agriculture, through the Farm Credit Administration, this situation has given rise to unprecedented governmental action.

Likewise taxes, the levies for the support of our numerous units of government, while not fixed at given levels by contract, have remained almost equally stationary in rate where, indeed, they have not actually increased. Many sources of government revenue are close to the business pulse of the nation. A slowing down of business activity brings with it a decline in government revenues. Government expenditures, on the other hand, are not easily decreased. Inevitably the government is, in addition, directly or indirectly faced with the new responsibility of coming to the aid of those who, often through no fault of their own, are no longer self-sustaining. The net result, at most, is but a slight abatement in the demand placed upon tax bases which are still fruitful or upon individuals who are still in position to contribute.

In California, in recent years, the most striking among the charges for support of government, which have shown little tendency towards decline, has been the general property tax. Devoted to the support of local units of government, this particular tax has symbolized the burden of taxation in general to perhaps a majority of the people of the state. From the standpoint of the farmer it is not too much to say that his visible tax problem begins and ends with this particular levy. Over a considerable period of years there is, undoubtedly, a tendency for property taxes to result in a lower value of the property that changes hands. The purchaser of land has his higher taxes compensated or partially compensated by lower overhead. The government takes, in short, a part of the return from the land which would otherwise go into private hands as a rate of return on a proportionately higher land value. When, however, farm earnings approach the vanishing point the burden of the property tax reappears in fullest force. Strictly speaking, land which is not earning a return above the costs of operation and remuneration of the operator does not have any economic value. Assessment for purposes of the property tax does not recognize this fine detail, however, and, while earnings from land may drop to a minimum or disappear entirely, assessments remain as a given percentage of a land value which has existed or it is assumed will return. The tax rate, it has been noted, is not likely to fall materially, and the results are a matter of all too common experience.

To the distressed farmer, or other property owner, two alternatives offer escape from the pressure of taxation which is unsustained by income and which gives promise of delinquency and dispossession. The levy may be shifted to other shoulders, presumably to those better able

to carry it, or the expenditures necessitating the tax may be curtailed. The campaigns for both of these adjustments have been conducted with vigor in recent years. Shifting of the tax burden was accomplished in some measure by the transfer of the counties' share of the school costs to the state and by the introduction of the retail sales tax.[4] These shifts have resulted in a small but appreciable reduction in the levy on property. Whether the use of the sales tax as a substitute for the general property tax can be justified on the basis of general equitability and ability to pay is an issue which cannot be raised here. It is sufficient to say that easing of tax burdens through a shifting to other groups involves the unfortunate but necessary consequence that other groups receive these burdens. While it seems certain that past legislative measures and the gradual evolution of the tax system have resulted in disruptive and perhaps unjust taxation, of which the general property tax is an example, there is need for the greatest care if changes are not to be similarly undesirable. In short, the easing of admittedly oppressive taxation through shifting of the burden cannot properly fail to carry with it the specification that the result be a closer approach to ideal principles of justice in the demands made upon the members of the community.

Downward adjustment of expenditures, the second of the alternatives for escape from taxation deemed unduly high, has also received its full share of attention in recent years. The cry for this form of adjustment in the public business is one in fact which may be partly stilled at times but which never completely dies. In periods of depression it becomes especially insistent as the fixed charges for taxation, as noted, come to occupy an ever larger place in the budget of the taxpayer.

Commonplace as have become the demands for economy and retrenchment of expenditure, it must be admitted that they have not had any very sweeping effect. New demands placed upon various units of government by the exigencies of depression have been noted as playing a part in keeping gross outlays to the levels previously obtaining or above. Further, and perhaps more important, there has been much confusion, particularly where the smaller units of governments are concerned, as to where the real costs of government lay and hence as to where really effective economies might be made. In particular, there has been a long perpetuated but little examined assumption that many of the revenues of governments are dissipated by waste and friction within the machine. Fruitless search for economies of this sort—painless because no sacrifice of public services is involved—has undoubtedly postponed reductions in expenditures for actual services which might well have been wel-

[4] Effected through approval by the people and enactment of the "Riley-Stewart" tax plan, Senate Constitutional Amendment No. 30. Voted June 27, 1933.

comed by a majority of the people. Finally, of course, even where there has been recognition of the need for forgoing accustomed services if expenditures were to be reduced, there has been much disagreement with reference to the services to be curtailed or eliminated.

In any case, the subject of governmental expenditures is one which remains confused, and the interest, discussion, and propaganda which it has attracted in recent years have inevitably had a mixed effect from the standpoint of general enlightenment. This situation is perhaps even more true of the local units of government than of state and national bodies. Avenues for a clear-cut focussing of public attention upon the latter are in many respects more effective than those for directing attention to the more somber happenings at the county courthouse and city hall.

It is toward the clarification of the expenditure situation of the California counties that this study is directed. The bringing of attention to bear upon the counties is in harmony with a tax system which makes them primarily dependent upon the general property tax, undeniably the major focus of the farmer's tax problem. Beyond this, however, is the permanent objective already noted of a clearer understanding of this phase of the public business.

METHOD OF STUDY

In order to handle better the large volume of statistical material necessary to a comprehensive view of the expenditures of California counties, the present analysis was organized into three stages.

In the first stage the expenditures of all (57)[5] counties for all purposes except debt redemption have been examined for the period from 1914–15 to 1931–32, and steps have been taken to break up the figures for total expenditures for all functions into their component parts. Thus, it has been possible to compare the increases in expenditure for education, highways, charities and corrections, and the other services and functions of county government and to assign to each of these the part which it has played in the movement in county expenditures as a whole since 1914–15.

In the second stage, the period of time for which county expenditures are considered has been shortened to a three-year average of the fiscal years 1929–30 to 1931–32. This shortening of the time period in turn has made possible the examination of different types of expenditures, not as a total figure for all counties combined but by individual counties and groups of counties. It has also made possible a more detailed scrutiny of the various classes of county expenditures.

[5] The City and County of San Francisco has been omitted from the study. (See page 107.)

In the third stage, which is a summary of the preceding material, steps have been taken to appraise the financial possibilities of various suggested reforms in county expenditures and, in particular, the effects of county consolidation upon the expenditures of California counties.

A general survey of a relatively broad field such as that of county expenditures in a state as large and diverse as California, necessarily leaves many specific questions unanswered. Where significant relations of a reasonably broad character have been indicated by the data and their analysis, these points have been given consideration. It has been necessary, however, to pass by many promising avenues for further investigation in the hope that the present study will at least provide a better background for attack thereon.[6]

It has been necessary throughout the study to view expenditures in an objective way without extended consideration of the sources of funds expended. Thus, while the general property tax is the mainstay of county revenues, state apportionments contribute to an important degree in the case of highways, education, and other services.[7] The county also draws smaller amounts from a variety of miscellaneous sources.

HISTORICAL ANALYSIS OF COUNTY EXPENDITURES[8]

It would have been strange, indeed, if county expenditures had not shown a marked increase during the past fifteen or twenty years. The population of the state doubled during this period; a generally lower dollar value made manifest in higher prices obtained much of the time; and with wealth, income, and living standards generally on the increase, new demands for public services accompanied the parallel growth in demand for more privately provided goods and services. Many have marvelled in recent times at what they choose to describe as a phenomenal growth in expenditures both state and local. It would have been truly phenomenal had there been no increase in expenditures under the conditions which existed during the last two decades.

THE TREND IN ALL EXPENDITURES

An increase for all counties was maintained, however, with scarcely an interruption from 1914–15 to 1930–31 (table 1, fig. 1). Likewise when Los Angeles, Alameda, and San Diego counties are excluded (Appendix

[6] In connection with the employment of material in this study as a basis for further research as well as in its application to other uses, the question of basic data employed is an important one. In Appendix A, the sources used in connection with this study are discussed in detail and the types of expenditures included and excluded are indicated in full.

[7] Where state funds make up an especially significant part of the expenditure, indication has been made of the amounts of such funds.

[8] Expenditures included under this heading are discussed in Appendix B.

B, page 108), the increase was general and uniform, although from 1914–15 until 1918–19 the rate of change was not particularly great—amounting to about 19 per cent. Expenditures of these 54 counties stood at $36,525,281 in 1914–15 and at $43,395,449 in 1918–19.[9] In 1919–20 they stood at $54,542,867 or 149 per cent of the 1914–15 level, and in 1920–21 at $78,103,698 or 214 per cent of the 1914–15 level. Thus, within the relatively short period of six years expenditures of the 54 counties had more than doubled. While the increase from 149 to 214 per cent of the 1914–15 base was the greatest relative increase within the period studied, it is of importance to recall that appropriations for expenditures in 1920–21 were made during the first half of 1920, and during this year the all-commodity index of wholesale prices recalculated to a corresponding base of 1915 = 100 reached an all-time peak of 222.[10]

No downward adjustment in county expenditures accompanied the fall in prices and reduction of money incomes during the depression of 1921. Expenditures of the 54 counties increased about 2 million dollars from 1920–21 to 1921–22, or from 214 to 219 per cent of the base year, and approximately 8.7 million during the following year, or from 219 to 243 per cent of 1914–15 expenditures. While an increasing price level and accompanying prosperity during the World War years and immediate post-war period apparently served—subject to some lag—to raise the level of county expenditures, the recession which followed seemed to have little influence in bringing a downward adjustment.

Not until 1924–25, in fact, did the first break occur in the hitherto steadily upward trend of county expenditures. While expenditures for all counties during the fiscal year 1924–25 were higher than in previous years, the expenditures of the 54 counties showed a decline of $3,815,452 or to 238 per cent of the 1914–15 level. In 1925–26 expenditures for the 54 counties again increased, although for that year they were still under the 1923–24 level. With the exception of a slight drop in 1928–29, expenditures continued to increase through the fiscal year ending June 30, 1931. In the latter year they stood at $118,258,889, or 324 per cent of the 1914–15 level. A slight drop to $111,800,457, or to 306 per cent of the 1914–15 level, occurred to 1931–32.

Except for miscellaneous disbursements, an expenditure grouping which appears to have varied in content over the period considered, there have been substantial increases in all of the county expenditure items since 1914–15 (tables 2 and 3, and fig. 2). From the standpoint of absolute amounts, by far the most important increase has been for educa-

[9] Reference throughout is to fiscal years ending on June 30 of the year given.

[10] Computation by author based on United States Department of Labor Bureau of Labor Statistics index.

TABLE 1

Total Expenditures of California Counties

Fiscal year	All counties*		54 counties†	
	Total expenditure	Per capita‡	Total expenditure	Per capita‡
1914-15	$ 59,537,225	$24.39	$ 36,525,281	$27.30
1915-16	63,636,081	25.08	38,929,221	28.29
1916-17	65,799,691	24.99	39,305,825	27.80
1917-18	64,459,817	23.63	41,645,481	28.68
1918-19	68,656,641	24.31	43,395,449	29.14
1919-20	88,328,458	30.25	54,542,867	35.71
1920-21	125,410,898	40.04	78,103,698	49.13
1921-22	139,089,957	41.58	80,007,572	48.43
1922-23	161,908,592	45.52	88,745,910	51.77
1923-24	179,405,566	47.60	90,849,518	51.14
1924-25	191,690,339	48.14	87,034,066	47.34
1925-26	212,401,015	50.64	89,621,912	47.16
1926-27	219,588,605	49.84	97,847,569	49.86
1927-28	235,173,309	50.93	104,906,394	51.79
1928-29	234,986,550	48.65	101,883,720	48.82
1929-30	248,277,907	49.24	107,242,082	49.89
1930-31	263,873,780	52.33	118,258,889	54.99
1931-32	$251,815,820	$49.93	$111,800,457	$52.02

* Excluding combined City and County of San Francisco.
† Excluding Los Angeles, Alameda, and San Diego counties.
‡ Population calculated upon basis of average annual increase during intercensus period.

Sources of data:

Computations by author based upon: Office of State Controller. Annual report of financial transactions of municipalities and counties of California, annual issues. California State Printing Office, Sacramento. (This publication is hereafter cited as "Financial transactions.")

United States Department of Commerce Bureau of the Census. Fifteenth Census of the United States, 1930. Population. Vol. 1: 127. 1932.

The Trend in County Expenditures, All Expenditures, 1914–15 to 1931–32

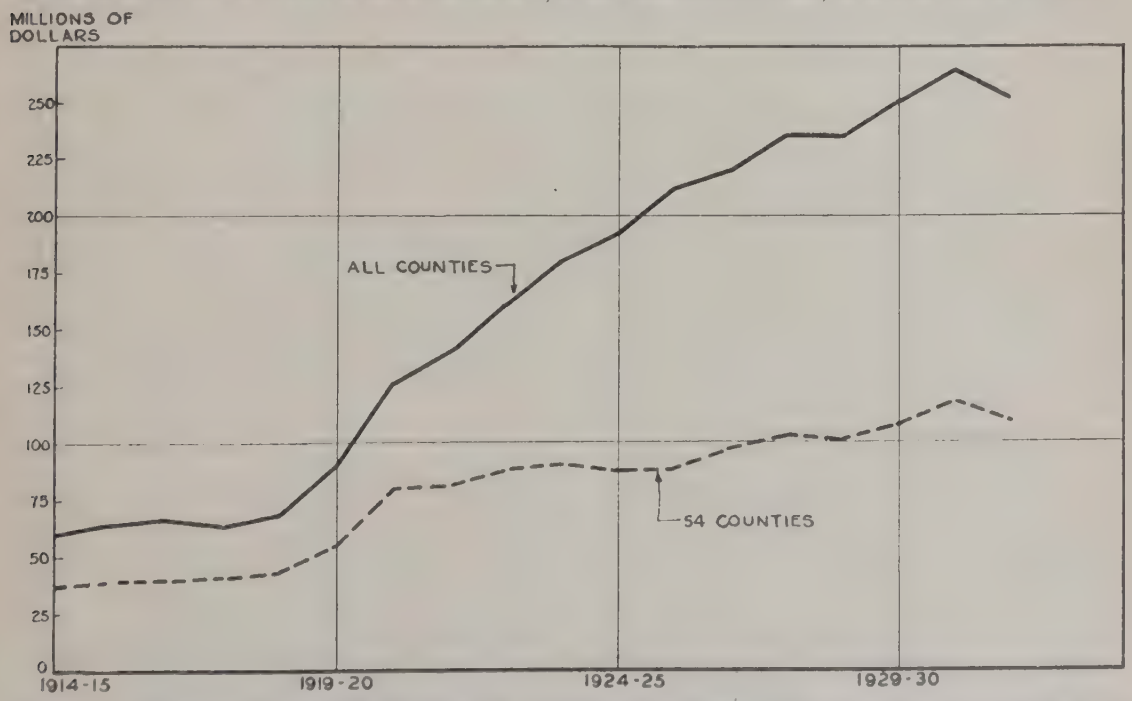


Fig. 1.—Expenditures of California counties increased with scarcely a break from 1914–15 to 1930–31. The City and County of San Francisco is not considered as a county in this study. (Data from table 1.)

TABLE 2

EXPENDITURES OF 54 CALIFORNIA COUNTIES BY MAJOR ITEMS

Fiscal year	Education	Highways	Charities and corrections	General government	Protection to persons and property	Health and sanitation	Recreation	Miscellaneous	Interest
1914-15	$14,736,762	$ 9,860,123	$ 2,273,615	$4,890,829	$1,722,828	$ 163,286	$ 45,044	$1,576,987	$1,255,807
1915-16	14,725,873	12,652,004	2,482,032	4,646,189	1,945,375	109,674	54,075	779,301	1,534,698
1916-17	15,410,042	11,668,105	2,805,904	4,960,105	2,019,042	149,096	42,607	412,213	1,838,711
1917-18	15,922,905	12,531,381	3,011,318	4,408,124	2,271,395	272,001	79,239	1,163,814	1,985,304
1918-19	16,388,614	10,230,577	3,332,753	5,344,217	2,260,912	428,922	82,074	3,193,423	2,133,957
1919-20	22,281,314	12,561,921	3,954,421	5,656,060	2,550,642	604,257	102,133	4,328,943	2,503,176
1920-21	37,184,019	21,116,501	4,528,444	6,424,390	2,957,265	734,707	143,042	1,602,794	3,412,536
1921-22	40,010,777	19,549,111	5,063,216	6,072,263	3,205,491	774,009	186,584	674,085	4,472,036
1922-23	47,624,437	17,279,949	5,539,162	6,886,593	3,698,917	750,082	300,509	1,155,494	5,510,767
1923-24	48,965,479	16,226,694	6,603,628	7,236,034	4,047,395	689,086	340,549	1,112,850	5,627,803
1924-25	45,349,771	15,870,946	6,497,412	7,347,866	3,767,652	927,257	419,833	958,570	5,894,759
1925-26	47,207,090	15,905,937	6,734,785	7,188,933	4,004,193	1,233,358	304,631	926,518	6,116,467
1926-27	52,050,726	16,401,680	7,157,881	8,765,269	4,223,154	1,446,581	724,052	896,279	6,181,947
1927-28	56,157,945	17,809,433	7,947,410	8,747,072	4,869,153	1,734,914	542,139	1,078,859	6,019,469
1928-29	53,968,370	16,431,792	8,092,054	9,107,220	4,937,329	1,730,755	413,285	1,169,259	6,033,656
1929-30	56,519,445	18,235,516	8,757,358	8,080,039	5,327,858	1,821,290	784,868	1,526,019	6,189,689
1930-31	63,702,774	18,532,422	10,256,857	9,782,386	5,841,304	2,046,013	845,860	1,321,065	5,930,208
1931-32	$59,814,076	$16,114,753	$11,450,225	$9,328,282	$5,431,493	$1,937,960	$582,764	$1,372,004	$5,768,900

Sources of data:

Computations by author based on: "Financial transactions;" and Budgets and Financial Reports of California counties on file at the Bureau of Public Administration, University of California, Berkeley.

tion, which for the 54 counties has expanded from approximately 15 million dollars in 1914–15 to four times that figure or approximately 60 millions in 1931–32. The greatest *relative* (percentage) increases have taken place in expenditures for health and sanitation and recreation, two much less important items. These in 1929–30 were approxi-

TABLE 3

Indexes of Expenditures of 54 California Counties by Major Items

Fiscal year	Education	Highways	Charities and corrections	General government	Protection to persons and property	Health and sanitation	Recreation	Miscellaneous	Interest
1914-15	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1915-16	99.9	128.3	109.2	95.0	112.9	67.2	120.1	49.4	122.2
1916-17	104.6	118.3	123.4	101.4	117.2	91.3	94.6	26.1	146.4
1917-18	108.1	127.1	132.5	90.1	131.8	166.6	175.9	73.8	158.1
1918-19	111.2	103.8	146.6	109.3	131.2	262.7	182.2	202.5	169.9
1919-20	151.2	127.4	173.9	115.7	148.1	370.1	226.7	274.5	199.3
1920-21	252.3	214.2	199.2	131.4	171.7	450.0	317.6	101.6	271.7
1921-22	271.5	198.3	222.7	124.2	186.1	474.0	414.2	42.8	356.1
1922-23	323.2	175.3	243.6	140.8	214.7	459.4	667.2	73.3	438.8
1923-24	332.3	164.6	290.5	148.0	234.9	422.0	756.0	70.6	448.1
1924-25	307.7	161.0	285.8	150.2	218.7	567.9	932.1	60.8	469.4
1925-26	320.3	161.3	296.2	147.0	232.4	755.3	676.3	58.8	487.1
1926-27	353.2	166.3	314.8	179.2	245.1	885.9	1,607.4	56.8	492.3
1927-28	381.1	180.6	349.6	178.9	282.6	1,062.5	1,203.6	68.4	479.3
1928-29	366.2	166.7	355.9	186.2	286.6	1,060.0	917.5	74.1	480.5
1929-30	383.5	184.9	385.2	165.2	309.3	1,115.4	1,742.5	96.8	492.9
1930-31	432.3	188.0	451.1	200.0	339.1	1,253.0	1,877.9	83.8	472.2
1931-32	405.9	163.4	503.6	190.7	315.3	1,186.9	1,293.8	87.0	459.4

Source of data: Computations by author based on table 2.

mately twelve times the 1914–15 level (table 3). Among the larger items of expenditure, charities and corrections have shown the largest relative increase, standing in 1931–32 at about five times the 1914–15 level. County expenditures for highways show only slight increase during this period and from 1920–21 to 1924–25 an actual decrease. This is not due, however, to an actual lessening of highway expenditures, but rather to extensive assumption by the state of the expense of highway construction and maintenance.

THE TREND IN EDUCATIONAL EXPENDITURE

Expenditure for education, with rare exceptions, has increased steadily throughout the period under consideration. During the years immediately following 1914–15, the increase was relatively slight, however, and until the fiscal year 1919–20 did not exceed the relative increase in all county expenditures for the 54 counties (tables 2 and 3 and fig. 3). Beginning with the latter year, however, there was a sharp upturn in

the expenditure level for this item which carried it, by 1922–23, to approximately 47.5 million dollars or to more than 300 per cent of the 1914–15 level. This was by far the most striking increase in any primary

INDEXES OF COUNTY EXPENDITURES FOR VARIOUS COUNTY SERVICES AND FUNCTIONS IN 54 COUNTIES, 1914–15 TO 1931–32. 1915 = 100

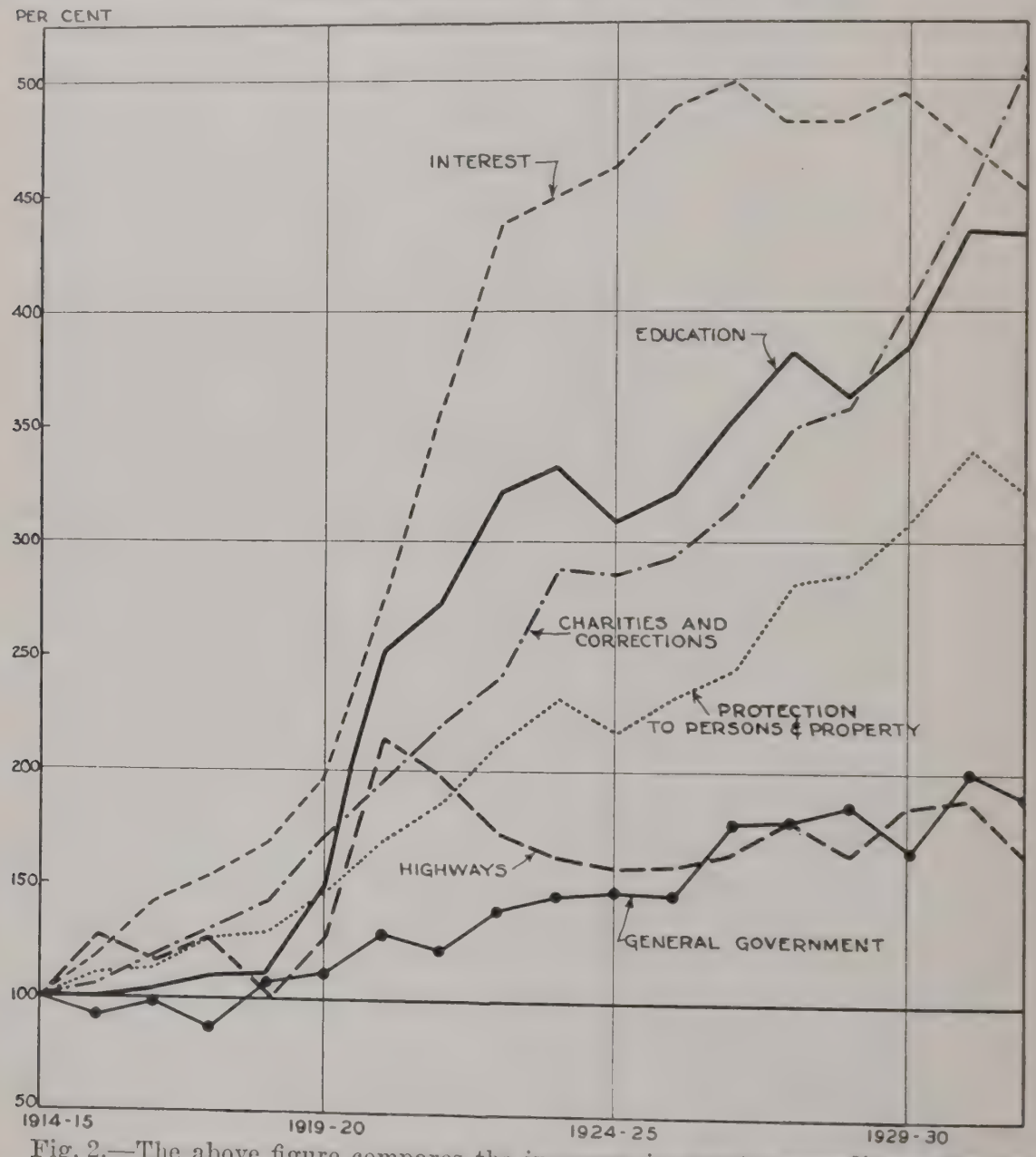


Fig. 2.—The above figure compares the increases in county expenditures for the more important of the services and functions of California counties. Expenditures for interest on indebtedness and charities and corrections, it will be noticed, show the greatest relative increase among the various items. (Data from table 3.)

item of expenditure of major importance during the period under consideration. Something of its character is to be gleaned from a comparison with expenditures for interest and indebtedness (table 3 and fig. 8). This item also showed a marked increase during the same period. Although a considerable increase in highway expenditures occurred at this

time, a close comparison of the trend in educational expenditure and that of interest on indebtedness shows that the former was apparently in

The Index of Expenditure for Education Compared with the Index of All Expenditure in 54 Counties, 1914–15 to 1931–32. 1915 = 100

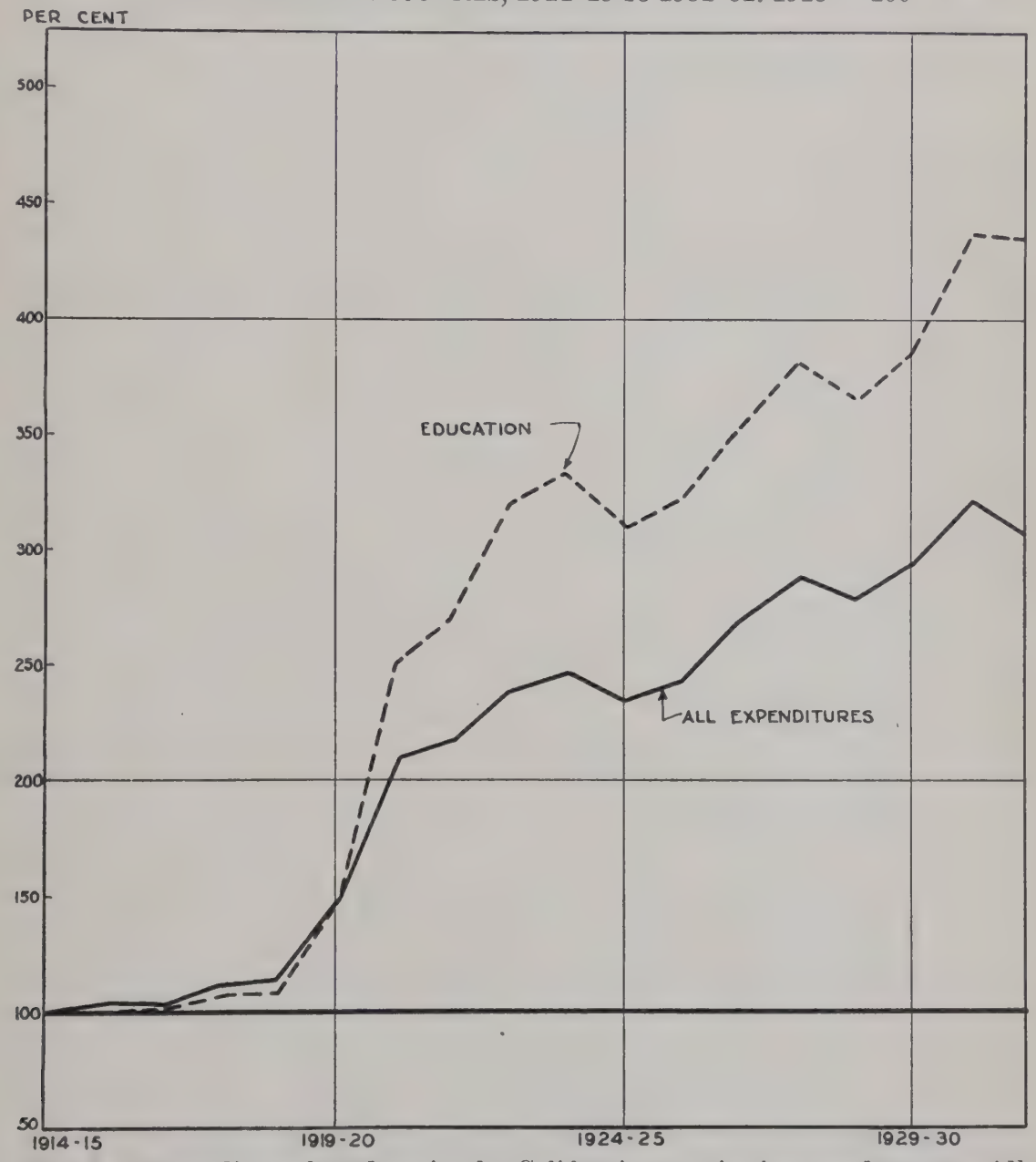


Fig. 3.—Expenditure for education by California counties increased more rapidly than did all county expenditures during the period from 1914–15 to 1931–32. (Data from table 3.) In this connection it should be recognized, however, that this is an expenditure which tends to increase with the number of individuals served; whereas certain types of county expenditure do not change greatly with increases in population. During this period population and numbers of pupils in the schools have practically doubled.

large part responsible for the latter. Increased salaries, larger attendance, and added services, as well as increases in the state apportionment for educational purposes, undoubtedly played an important part in increasing expenditure for education. There is little question, however,

that the demand for new buildings and other permanent equipment, partly restrained by shortages and high costs of materials during the War, was a major factor. Bond issues, which raised the annual disbursement for interest on indebtedness from approximately 2 million dollars in 1918–19 to approximately 5.5 million dollars in 1922–23, were a major factor in paying the bill.

The increase in educational expenditure has been at a much more moderate rate since 1923–24. In fact, expenditures for 1924–25 and 1925–26 were slightly under the 1923–24 level. By 1931–32, however, another 70 per cent of increase over the 1914–15 level had been added. An interesting point is that this later increase has been unaccompanied by any significant increase in the payments for interest on indebtedness. Throughout this period, educational expenditures stood well above the general level of increase (fig. 3).

It is important to recall that not all of the increase in educational expenditure from $14,736,762 for the 54 counties in 1914–15 to $59,814,076 in 1931–32 was provided by the general property tax or local revenue sources, although these did contribute a major share of the increment. State apportionment of elementary and high school funds in 1914–15 amounted to approximately $3,735,000 and by 1920–21 had increased to approximately $4,530,000. An increase in the rate of apportionment, as well as the increase in population, brought the state's contribution to $10,191,000 in 1924–25 with a further increase to approximately $12,165,000 in 1929–30. There was an increase of still another million dollars to 1931–32.[11]

THE TREND IN HIGHWAY EXPENDITURE

During the past decade the importance of the county as a source of funds for financing highways has steadily declined. The state's participation in this activity has increased enormously during this time. Table 3 and figure 4 pertain only to the expenditures made by the counties. In the peak year of 1920–21, expenditures for highways stood at slightly more than 21 million dollars or about 215 per cent of the 1914–15 level. Since 1924–25 they have ranged between 16 million and 18.5 million dollars or from 160 to 190 per cent of the 1914–15 level.

This virtually reverse trend in expenditure for roads does not indicate, however, that there has been any decline in the volume of construction or, otherwise expressed, in the volume of public services in the form of highway improvement that has been made available during this period.

[11] Data from: California Office of Controller. Annual report of financial transactions of municipalities and counties of California, annual issues, 1915 to 1932. California State Printing Office, Sacramento. (This publication is hereafter cited as "Financial transactions.")

Rather it indicates the gradual displacement of the county by the state from the position of public "road-builder." When county expenditures reached their peak of $21,116,501 in 1920–21, the expenditures of the

The Index of Expenditure for Highways Compared with the Index of all Expenditure in 54 Counties, 1914–15 to 1931–32. 1915 = 100

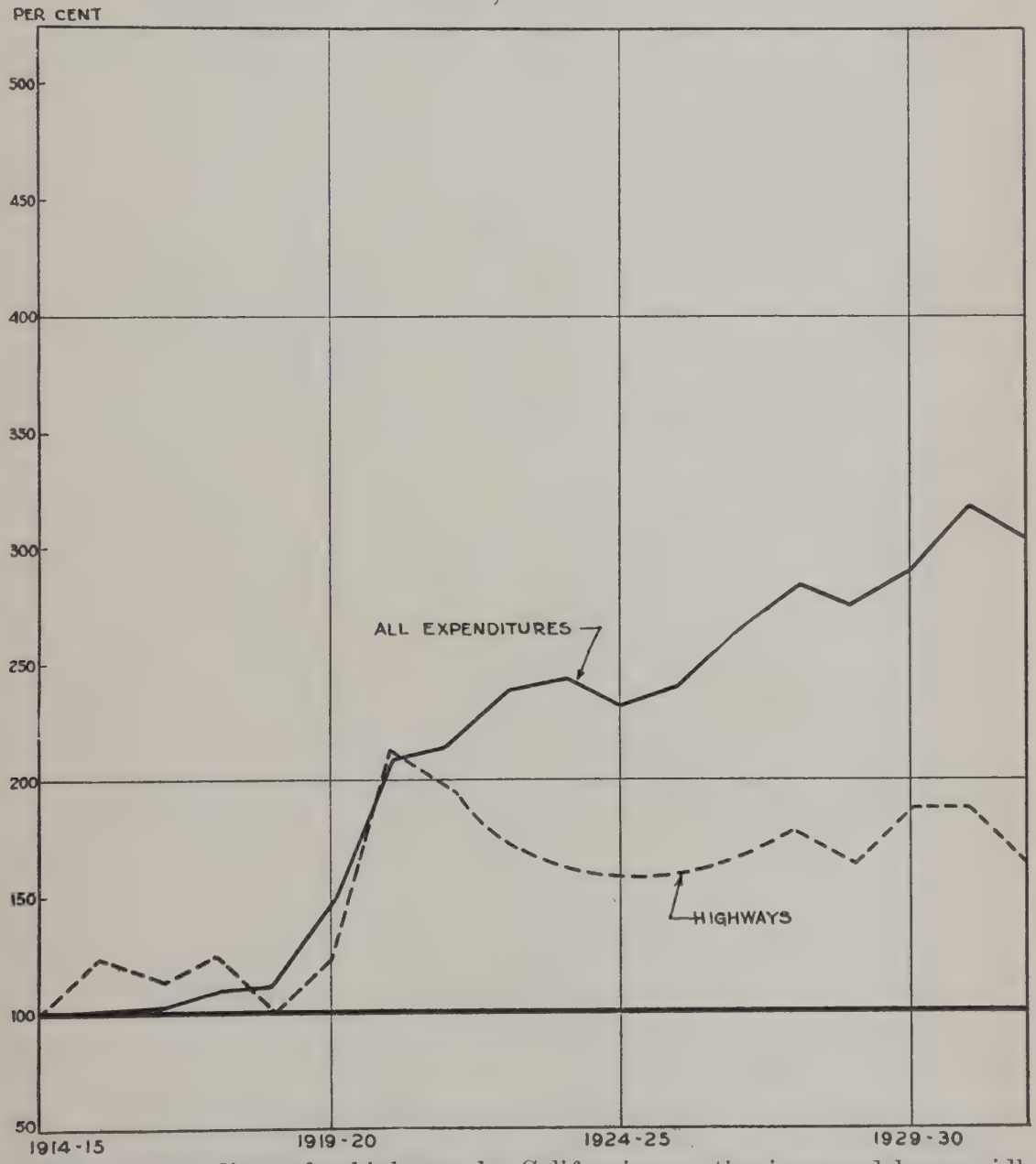


Fig. 4.—Expenditure for highways by California counties increased less rapidly than all county expenditures, reaching its peak for the period shown in 1920–21. This slower rate of increase in highway expenditures should be interpreted in the light of extensive transfers of highway construction and maintenance expenditure to the state. (Data from table 3.)

California State Division of Highways from all funds amounted to $8,868,248.[12] Although county highway expenditures had decreased $5,001,748 by 1931–32, expenditures of the California State Division of

[12] California Department of Public Works Division of Highways. Eighth Biennial Report, p. 238. November, 1932.

Highways had increased by $26,703,577 to this year or by more than five times the decrease in county expenditure. It is also to be recognized that an increasing share of the counties' decreasing highway expenditures was being provided by state subvention of gasoline and motor-vehicle tax funds during this period.

THE TREND IN EXPENDITURES FOR CHARITIES AND CORRECTIONS[13]

The movement in expenditures for charities and corrections since 1914–15 has been a particularly interesting one. This item or group includes the expenditure for the county physician, the county hospital, and the county almshouse, the probation officer and his court, the inmates of reform schools and homes for the feeble minded and insane, the care of indigent children and the maintenance of indigents outside of the almshouse. This last item in recent times has come to occupy a considerable place in the public mind under the more familiar and perhaps more appropriate title of "relief."[14] Among all groups of expenditures, that for charities and corrections has shown the most consistent increase throughout the period under consideration (fig. 2). This increase, from a relative standpoint, has also been the greatest of any major county disbursement. In 1914–15 expenditures for charities and corrections by the 54 counties stood at approximately 2.3 million dollars (table 2). Six years later, in 1920–21, it had approximately doubled or was about 200 per cent of the 1914–15 level (table 3). By 1925–26, or in another five years, it had increased by approximately another 100 per cent of the 1914–15 level. Four years more added another increase of 100 per cent of the 1914–15 level, bringing this expenditure to approximately four times the 1914–15 expenditure in the fiscal year 1929–30, or to twice the expenditure for 1920–21. As might be expected, further heavy increases occurred in 1930–31 and 1931–32 bringing expenditures in the latter year to about five times the 1914–15 level. Expenditure in 1931–32 was about 11.5 millions as compared with 2.3 millions in 1914–15.

That an increasing expenditure under this heading is not in any way peculiar to periods of depression is significant. The depression of 1921 is wholly unreflected in the regular increase in this expenditure during the period from 1918–19 to 1923–24 (fig. 5).

In relating the increase in expenditure for charities and corrections to

[13] A more descriptive title would be "Charities, Hospitals, and Corrections," as employed by the Bureau of the Census to cover similar items in its revised series on financial statistics of state and local governments. See the first of this series: United States Department of Commerce Bureau of the Census. Financial statistics of state and local governments, 1931, Virginia. p. 1–45. 1933.

[14] In the State Controller's classification, which is followed here, expenditures for jails since 1913–14 have been included under "protection to persons and property" rather than under "charities and corrections."

the general increase in county expenditures, it should be remembered that this item—important though it is—does not comprise anything like a predominant part of the whole. Even in 1931–32, a year when this

The Index of Expenditures for Charities and Corrections Compared with the Index of All Expenditures in 54 Counties, 1914–15 to 1931–32.
1915 = 100

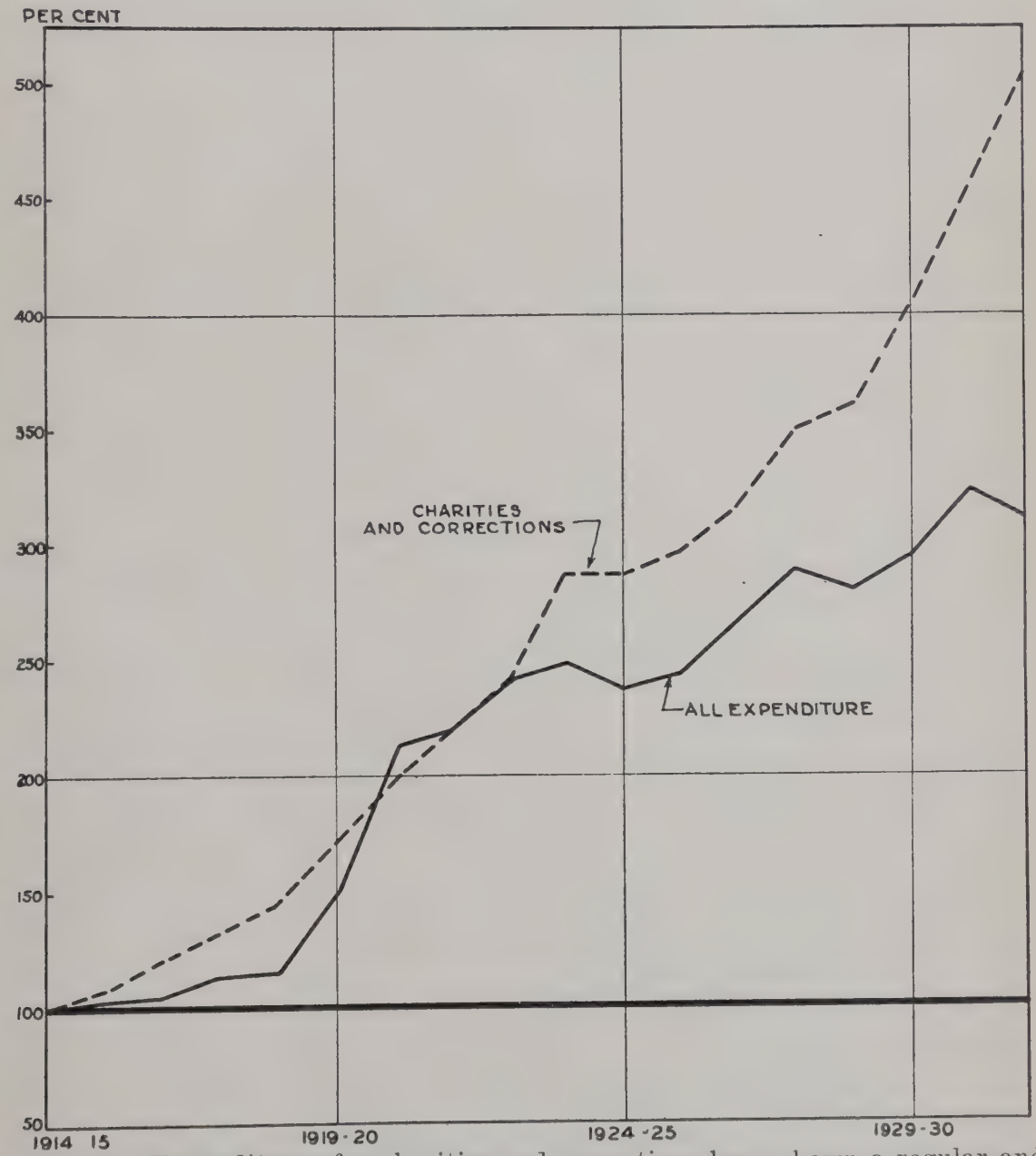


Fig. 5.—Expenditures for charities and corrections have shown a regular and rapid increase during the period considered which substantially exceeded that for all expenditures combined. (Data from table 3.)

expenditure showed a large increase in the face of slightly decreasing expenditures for other groups, it comprised but slightly more than one-tenth of county expenditure as a whole. The part played by the various county expenditures in contributing to the total increase is indicated later.

THE TREND IN EXPENDITURE FOR GENERAL GOVERNMENT

Expenditure for general government falls in a somewhat different category from the other expenditure groups. The concern here is with a type of expenditure which in considerable part contributes but indirectly to the services for which county governments exist. Expenditures for the assessing of property, the levying and collecting of taxes and administering of county finances, and the holding of elections for county officers concerned with the above activities, for example, could scarcely be justified, except as they make possible the performance of the actual services such as education, provision of health services, and institutions. In other words, expenditure for general government represents in considerable degree the expenditure for the *overhead* in county government—that which makes possible the performance of other county functions, but which contributes only indirectly.

Needless to say, the above characterization of general government expenditure is not true of all the expenditures grouped under this heading. The counties' contribution to administration of justice, included under this heading, is for a direct service; in fact it is one of the most venerable of the functions not alone of the American county, but also of its English ancestor.[15] Legislative functions of the Board of Supervisors must be considered a direct service and also certain of the activities of the county clerk. Modern trends in size and architectural magnificence of the county courthouse lead inevitably to the conclusion that expenditure in this connection is more or less of a direct service to community pride.

The expenditure for general government has partaken of the prevailing upward trend, although with the exception of highways the increase here has been the least marked of that for any group.[16]

The increase in expenditure for general government has been fairly uniform, although subject to some year-to-year variation, particularly under the influence of expenditures for elections in certain years and capital outlays for courthouses in certain counties from time to time. In 1914–15 the expenditure for general government by the 54 counties was slightly less than 5 million dollars (table 2), or a little more than double the expenditure for charities and corrections. The increase during the War years was relatively slight, in fact, the expenditures for general

[15] Farlie, John A., and Charles M. Kneir. County government and administration. p. 8–12. Century Co., New York. 1930.

[16] As indicated by table 3, an actual decrease has occurred in the small group of miscellaneous expenditures. The changing constituents of this group and its mixed character have led to its omission from present comparisons. See page 24.

government in the fiscal year 1917–18 were smaller than in 1914–15. A fairly steady increase began in 1918–19 which was carried through the following decade. In 1924–25 this expenditure was approximately 7.3

The Index of Expenditure for General Government Compared with the Index of All Expenditures in 54 Counties, 1914–15 to 1931–32. 1915 = 100

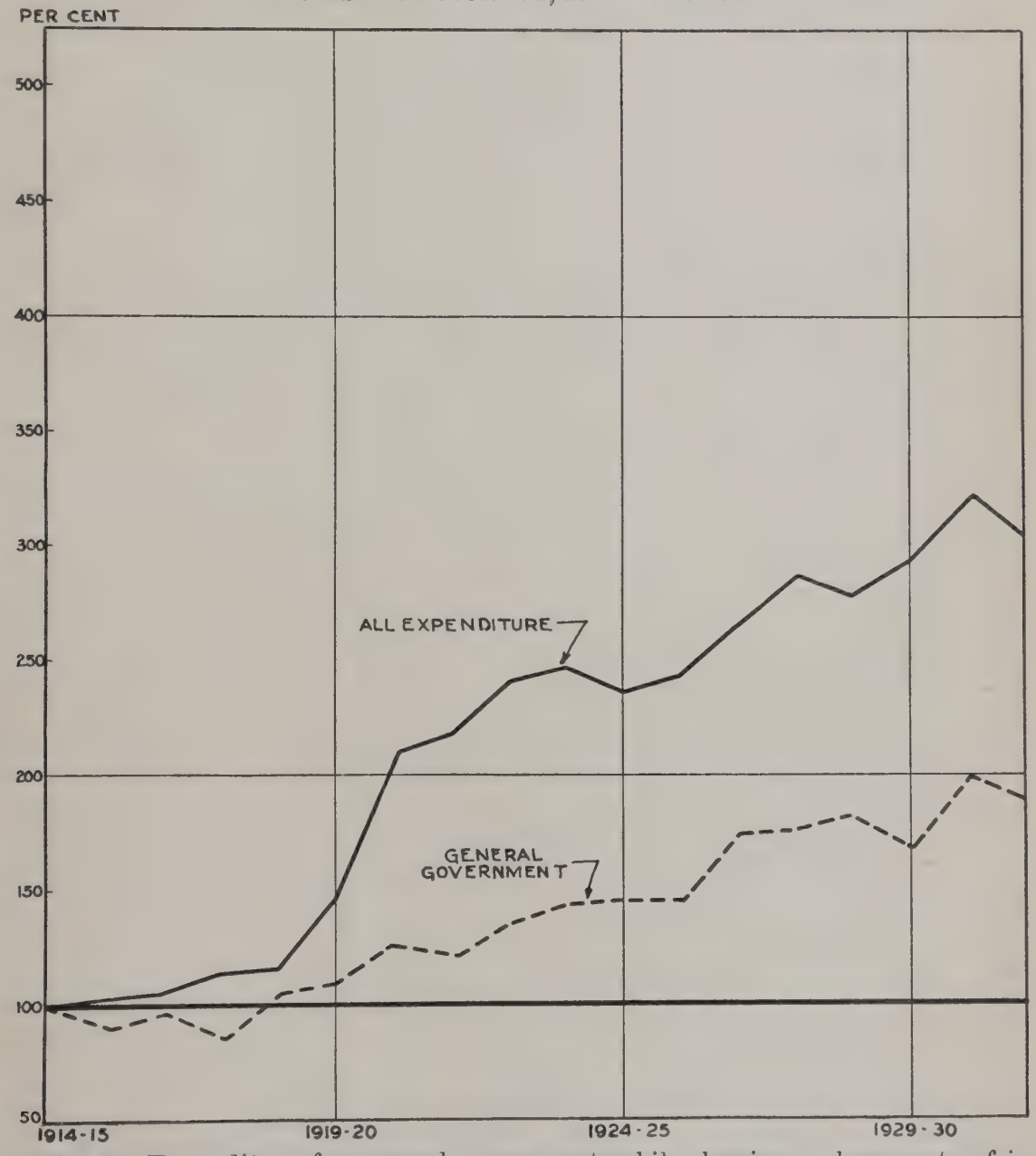


Fig. 6.—Expenditure for general government, while showing a slower rate of increase than that for all expenditure, has approximately doubled during the period considered. (Data from table 3.)

million dollars or 150 per cent of the 1914–15 level (table 3). In the same year, expenditures for charities and corrections amounted to about 6.5 millions which, however, was 285 per cent of the amount expended in the base year for this group of services. A high point of approximately 9.8 million dollars for general government was reached in 1930–31 (fig. 6) which was approximately 200 per cent of the 1914–15 level. However,

election expenditures in this year (1930–31) were well in excess of a million dollars, as compared with approximately $125,000 for the preceding year. In 1930–31 expenditures for charities and corrections actually exceeded expenditures for general government, standing at about 450 per cent of the 1914–15 level.

By observing the trend of expenditures for general government as a whole, there appear to be two important reasons for the slower increase in this item. As far as these expenditures have the character of *overhead*, there is some reason for believing that an increase in population (and wealth) results in a somewhat more efficient utilization of existing machinery. Within certain limits there has come to be a certain nucleus of county officialdom which every county, large or small, must support. An increase in county population may thus result in a fuller utilization of existing organization at no great increase in cost. It would appear that a certain, if unknown, part of the slower increase in expenditures for general government may be related to this situation.

A second reason for the slower increase in expenditures for general government rests with the more obvious fact that there has been a smaller increase in the demands for higher levels of public service in this item. Such part of the general increase in county-expenditure levels as has resulted from new demands for public services or a higher standard in existing services has had but little effect on this item. Some enthusiasm, it is true, can be generated in a campaign for a new courthouse, but one for more or better assessing, tax collecting, or auditing, has small popular appeal indeed. Even the machinery for administration of justice has become cooled in an earlier mold and little serious demand for improvement or revision has been made beyond that necessary to meet the needs of mere "volume of business."

The slower increase in expenditure for general government, it may be noted, does not bear proof of comparative economy in past administration of general government nor of the justifiability of present levels of expenditure. The two reasons for the slower increase which have been noted are unrelated to any efforts towards economy in this item of expenditure. Subsequent analysis indicates, in fact, that the present adjustment of general government or *overhead* to other county services and to population is far from efficient in many California counties.

THE TREND IN EXPENDITURE FOR PROTECTION TO PERSONS AND PROPERTY

The classification of services for "Protection to Persons and Property," as employed by the Controller, is a rather general one and covers, as a matter of fact, not one but two groups of services. The first of these

The Index of Expenditure for Protection to Persons and Property Compared with the Index of All Expenditures in 54 Counties, 1914–15 to 1931–32. 1915 = 100

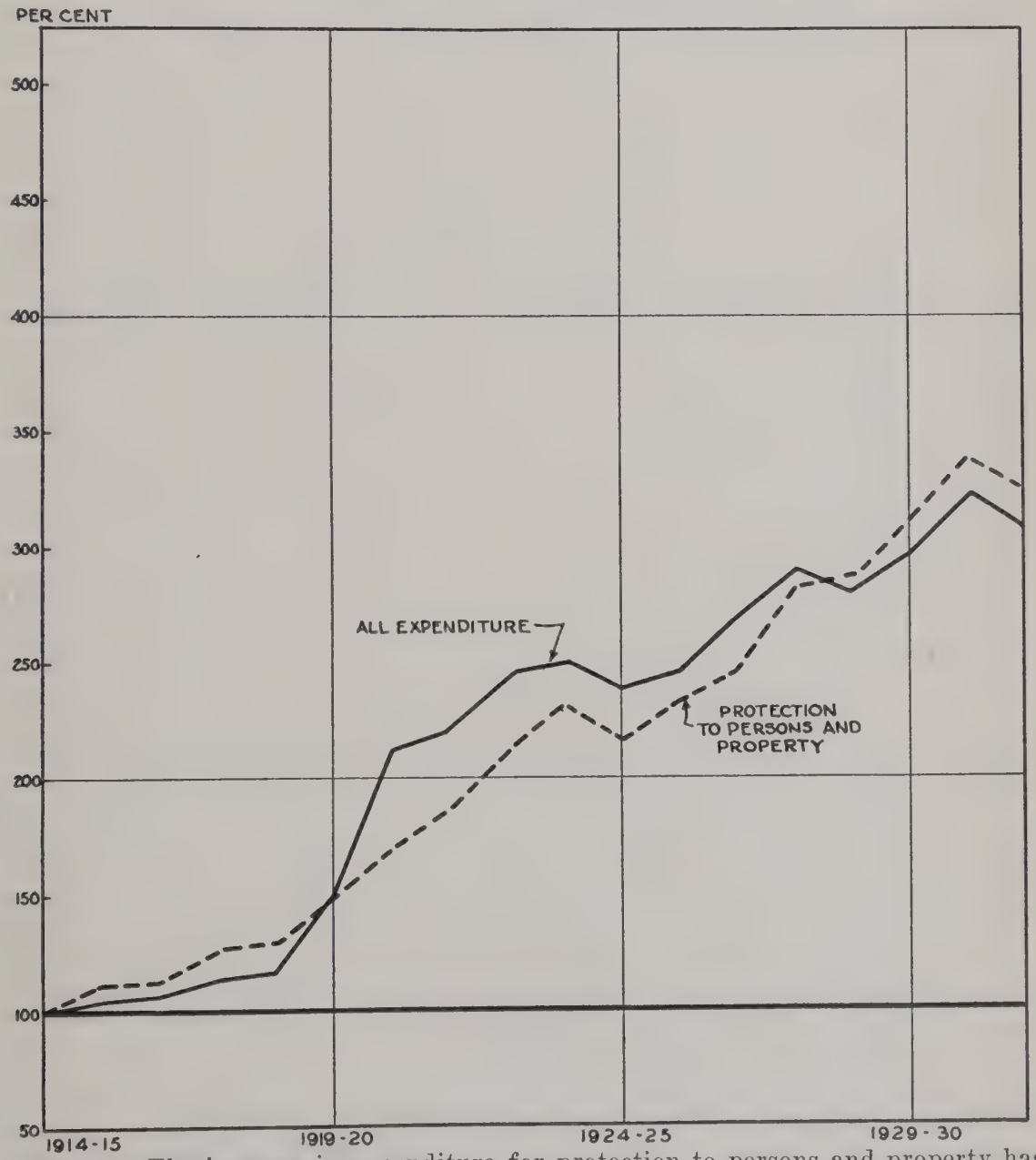


Fig. 7.—The increase in expenditure for protection to persons and property has approximated the increase in all expenditures since 1914–15, standing in 1931–32 at approximately 315 per cent of the 1914–15 level. (Data from table 3.)

includes the support of the sheriff, constables, and jails. Aside from the civil functions of the first-mentioned officer, it largely covers the enforcement of criminal laws. The second group of services covers the multitude

of activities of the county in protecting property, or, more strictly speaking, improving economic welfare within its borders.[17] It is desirable that the dual character of this grouping—as well as the somewhat miscellaneous character of the second part—be kept in mind in considering the trend in expenditure levels.

The relative increase in the expenditure by the 54 counties for protection to persons and property from 1914–15 to 1931–32 has been slightly greater than for all expenditures combined (fig. 7). The upward trend, like that for charities and corrections, has been uniform and consistent

TABLE 4

COMPARATIVE INCREASE IN GROUPS OF EXPENDITURES CLASSIFIED UNDER PROTECTION TO PERSONS AND PROPERTY

(54 counties)

Year	Sheriff's office, jails, and constables	Per cent of 1914-15	Per cent of total for protection to persons and property	Other expenditures for protection to persons and property*	Per cent of 1914-15	Per cent of total for protection to persons and property
1914–15	$ 854,987	100	50	$ 867,842	100	50
1922–23	1,430,455	167	39	2,268,459	261	61
1931–32	$2,225,342	260	41	$3,206,152	369	59

* See table 18 for items.

Source of data: Computations by author based on "Financial transactions."

over the period studied; in fact, but two years, 1924–25 and 1931–32, show a decline from the years preceding. In 1914–15, expenditure was approximately 1.7 million dollars (table 2). By 1922–23 it had a little more than doubled, as compared with educational expenditure which had more than tripled by this year and expenditures for charities and corrections which were approximately three times their 1914–15 level. Between 1922–23 and 1930–31 expenditure for protection to persons and property increased by slightly over 2 million dollars, standing in the latter year at about 340 per cent of the base year (table 3). In 1931–32 expenditures for this item were 315 per cent of the 1914–15 level representing a slightly more than threefold increase during the eighteen-year period.

In 1914–15 about $850,000 or approximately 50 per cent of the expenditures by the 54 counties for protection to persons and property were devoted to the support of the sheriff's office, maintenance of the county jail and inmates, and payment of constables. In the intervening years to 1931–32, expenditures for these purposes have increased, stand-

[17] See pages 70 to 71. A partial list of these activities for purposes of illustration includes such services as the provision of county warden, farm advisor, agricultural commissioner, bee inspector, inspector of weights and measures, and forest and fire protection.

ing at $1,430,455 or 167 per cent of the 1914–15 level in 1922–23 and at $2,225,342 or 260 per cent of the base year in 1931–32. Expenditures for the multitude of services to the economic life and welfare of the county, however, have shown a more rapid increase than those for law enforcement and control of crime.[18] In 1914–15 they approximately equaled expenditures for the sheriff's office, etc., but by 1922–23 they were approximately $750,000 greater and by 1931–32 nearly $1,000,000 greater. Figures for these three years which are illustrative of the general trend are shown in table 4. The increase in county expenditure resulting from extension of county inspection, regulatory, and educational services, particularly for agriculture, appear to be responsible for at least the difference in increase between the two groups shown in table 4.

THE TRENDS IN HEALTH, RECREATIONAL, AND MISCELLANEOUS EXPENDITURES

By far the greatest relative increase among the various groups of county expenditures has taken place in two comparatively minor items of expenditure. Expenditures for health and sanitation covering support of the health officer,[19] control of contagious disease, maintenance of a tubercular hospital in certain cases, the eradication of disease carriers, sanitary inspection, and other services, have increased by about twelvefold since 1914–15 (tables 2 and 3). There is little doubt that increased levels in this item are very largely a result of increased levels of service, although it would seem reasonable that, in contrast with such an item as general government, increasing density of population may bring more than proportional increase in the expenditure necessary to maintain high standards of health protection.[20]

Expenditure for recreation, while still a relatively insignificant part of the total, has also shown a large relative increase during the period

[18] Together, of course, with those for the civil functions of the sheriff's office.

[19] In certain counties many of the services here listed are incorporated into the activities of the "County health unit," a full-time branch of the county government charged with public activities relating to the health of the residents. See: California Department of Public Health. Thirty-first Biennial Report, July 1, 1928, to June 30, 1930. p. 11. 1931.

[20] That this is apparently the case is strikingly illustrated by a comparison of rates of population increase and rates of increase in expenditure for protection of health in the rural and metropolitan counties. In 1930, population in the three metropolitan counties of Los Angeles, Alameda, and San Diego was approximately 208 per cent of the 1920 level, representing an increase of 108 per cent; in the remaining 54 counties it was approximately 141 per cent, or an increase of 41 per cent. For 1929–30, health expenditure in the metropolitan counties was 1,627 per cent of the 1919–20 level, an increase of 1,527 per cent; in the remaining counties it was 301 per cent of 1919–20, or an increase of 201 per cent. Thus, during the period in question, each 1 per cent increase in population in the densely populated counties coincided with a 14 per cent increase in health expenditure; in the other counties a 1 per cent increase in population coincided with but a 5 per cent increase in expenditure for health services.

studied. This item shows considerable fluctuation from year to year under the influence of capital outlays for parks or other county recreational facilities.

THE INDEX OF EXPENDITURE FOR INTEREST ON INDEBTEDNESS COMPARED WITH THE INDEX OF ALL EXPENDITURES IN 54 COUNTIES, 1914–15 TO 1931–32. 1915 = 100

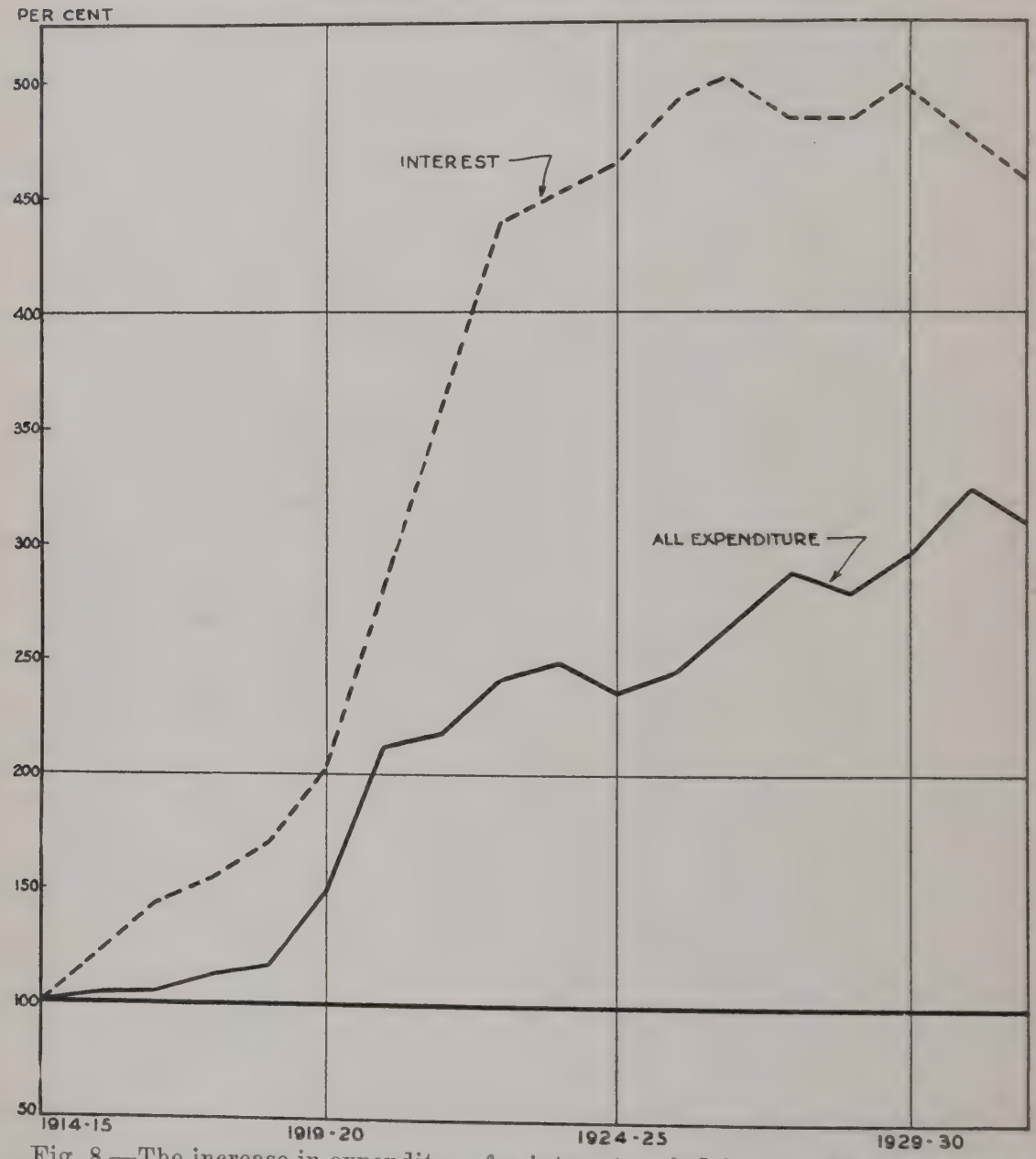


Fig. 8.—The increase in expenditure for interest on indebtedness has been greater than that for any other major item of county expenditure. Much of the increase in this expenditure is the result of increased school district indebtedness and it corresponds closely to the increase in educational expenditure shown in figure 3. (Data from table 3.)

Miscellaneous expenditure covering county advertising, exhibits at fairs, "payments to correct errors" and other items has fluctuated widely during the period under consideration but has shown no general increase. As earlier mentioned, this group has suffered the inevitable varia-

tion in composition which is the lot of a "catch-all" grouping, and comparisons over a period of years are without significance. It may be noted that it is of relatively small importance in the total, amounting to but little more than 1 per cent of all expenditure.

THE TREND IN EXPENDITURE FOR INTEREST ON INDEBTEDNESS

The increasing levels of bonded indebtedness of California counties are sharply reflected in the course of payments of interest on indebtedness in the past eighteen years. In 1914–15 expenditure for interest on indebtedness by the 54 counties (including district indebtedness, pre-

TABLE 5

Comparative Increase in County and District* Indebtedness, 1917–18 to 1924–25

(54 counties)

Year	Interest on district bonds	Interest on county bonds
1917–18	$ 892,926	$1,092,378
1918–19	1,000,206	1,133,751
1919–20	1,069,089	1,434,087
1920–21	1,417,225	1,995,311
1921–22	2,210,813	2,261,223
1922–23	3,102,557	2,408,210
1923–24	3,273,911	2,353,892
1924–25	$3,926,599	$1,968,160

* Primarily school and road districts. See page 105, Appendix A.

Source of data: Compiled by author from "Financial transactions."

dominantly that of school districts[21]) amounted to approximately 1.25 million dollars (table 2 and fig. 8). By 1919–20 the annual payment for interest had approximately doubled. The increase in educational expenditures which began in earnest in the latter years was reflected in an even sharper increase in expenditures for interest (fig. 2), and for the next three years interest payments by the 54 counties expanded at the rate of about a million dollars a year. While interest on county indebtedness shared in the advance, district expenditures for interest showed an even more rapid increase (table 5). As previously indicated, this reflects the large portion of the increased indebtedness which was devoted to the financing of school construction.

Since 1922–23 the upward trend in expenditure for interest has been at a much slower rate; in fact, there has been little or no increase since 1926–27, and beginning with 1929–30, the trend in expenditure for this item has been definitely downward. There is little doubt that the peak in

[21] See page 105, Appendix A.

indebtedness has been passed. Provided of course that new issues do not replace the maturities of 1919–20 to 1922–23 borrowing, there should be a further substantial decline. It will be agreed that this is one favorable omen at least in county finance.

TABLE 6

INCREASE IN ITEMS OF COUNTY EXPENDITURES AND PROPORTION OF TOTAL INCREASE ATTRIBUTABLE TO EACH
(54 counties)

Classifications Concluded on Opposite Page

Year	Total increase in expenditures over 1914-15	Education		Highways		Charities and corrections		General government	
		Increase	Per cent of total increase	Increase	Per cent of total increase	Increase	Per cent of total increase	Increase	Per cent of total increase
1915–16	$ 2,403,940	$ −10,889	−0.5	$2,791,881	116.1	$ 208,417	8.7	$−244,640	−10.2
1916–17	2,780,544	673,280	24.2	1,807,982	65.0	532,289	19.1	69,276	2.5
1917–18	5,120,200	1,186,143	23.2	2,671,258	52.2	737,703	14.4	−482,705	− 9.4
1918–19	6,870,168	1,651,852	24.1	370,454	5.4	1,059,138	15.4	453,388	6.6
1919–20	18,017,586	7,544,552	41.9	2,701,798	15.0	1,680,806	9.3	765,231	4.3
1920–21	41,578,417	22,447,257	54.0	11,256,378	27.0	2,254,829	5.4	1,533,561	3.7
1921–22	43,482,291	25,274,015	58.1	9,688,988	22.3	2,789,601	6.4	1,181,434	2.7
1922–23	52,220,629	32,887,675	63.0	7,419,826	14.2	3,265,547	6.3	1,995,764	3.8
1923–24	54,324,237	34,228,717	63.0	6,366,571	11.7	4,330,013	8.0	2,345,205	4.3
1924–25	50,508,785	30,613,009	60.6	6,010,823	11.9	4,223,797	8.4	2,457,037	4.9
1925–26	53,096,631	32,470,328	61.1	6,045,814	11.4	4,461,170	8.4	2,298,104	4.3
1926–27	61,322,288	37,313,964	60.8	6,541,557	10.7	4,384,266	8.0	3,874,440	6.3
1927–28	68,381,[illegible]3	41,421,183	60.6	7,949,310	11.6	5,673,795	8.3	3,856,243	5.6
1928–29	65,358,439	39,231,608	60.0	6,571,669	10.0	5,818,439	8.9	4,216,391	6.5
1929–30	70,716,801	41,782,683	59.1	8,375,393	11.9	6,483,743	9.2	3,189,210	4.5
1930–31	81,733,608	48,966,012	59.9	8,672,299	10.6	7,983,242	9.8	4,891,557	6.0
1931–32	$75,275,176	$45,077,314	59.9	$6,254,630	8.3	$9,176,610	12.2	$4,437,453	5.9

Source of data: Computations by author based on table 2.

COMPARATIVE IMPORTANCE OF THE INCREASES IN EXPENDITURE FOR VARIOUS ITEMS

In the foregoing analysis of the trends in the various items of county expenditures, major emphasis has been placed upon the rate of increase in these individual items. Equally significant with this, from the standpoint of interpreting the increase in county expenditures as a whole, is the part which the increase in each item has played in contributing to the total increase, that is, the proportion of the increase in total expenditures which is to be charged to increased expenditure for education, highways, and other items.

The total increase in expenditures of the 54 counties over 1914–15 in each subsequent year has been set forth in table 6. This total has then been divided among the various individual items accordingly as they

have been responsible for the increase. An examination of the table and of figure 9 leaves little doubt as to the items of expenditure which must bear major responsibility for the increase in total expenditure levels of the 54 counties during this period. The increase in educational expenditure,

TABLE 6—*(Concluded)*

Increase in Items of County Expenditures and Proportion of Total Increase Attributable to Each

(54 counties)

Protection to persons and property		Health and sanitation		Recreation		Miscellaneous		Interest—county and district bonds	
Increase	Per cent of total increase	Increase	Per cent of total increase	Increase	Per cent of total increase	Increase	Per cent of total increase	Increase	Per cent of total increase
$ 222,547	9.3	$— 53,612	—2.2	$ 9,031	0.4	$—797,686	—33.2	$ 278,891	11.6
296,214	10.7	— 14,190	—0.5	— 2,437	—0.1	—1,164,774	—41.9	582,904	21.0
548,567	10.7	108,715	2.1	34,195	0.7	— 413,173	— 8.1	729,497	14.2
538,084	7.8	265,636	3.9	37,030	0.5	1,616,436	23.5	878,150	12.8
827,814	4.6	440,971	2.4	57,089	0.3	2,751,956	15.3	1,247,369	6.9
1,234,437	3.0	571,421	1.4	97,998	0.2	25,807	0.1	2,156,729	5.2
1,482,663	3.4	610,723	1.4	141,540	0.3	— 902,902	— 2.0	3,216,229	7.4
1,976,089	3.8	586,796	1.1	255,465	0.5	— 421,493	— 0.8	4,254,960	8.1
2,324,567	4.3	525,800	1.0	295,505	0.5	— 464,137	— 0.8	4,371,996	8.0
2,044,824	4.0	763,971	1.5	374,789	0.7	— 618,417	— 1.2	4,638,952	9.2
2,281,365	4.3	1,070,072	2.0	259,587	0.5	— 650,469	— 1.2	4,860,660	9.2
2,500,326	4.1	1,283,295	2.1	679,008	1.1	— 680,708	— 1.1	4,926,140	8.0
3,146,325	4.6	1,571,628	2.3	497,095	0.7	— 498,128	— 0.7	4,763,662	7.0
3,214,501	4.9	1,567,469	2.4	368,241	0.6	— 407,728	— 0.6	4,777,849	7.3
3,605,030	5.1	1,658,004	2.3	739,824	1.0	— 50,968	— 0.1	4,933,882	7.0
4,118,476	5.0	1,882,727	2.3	800,816	1.0	— 255,922	— 0.3	4,674,401	5.7
$3,708,665	4.9	$1,774,674	2.4	$ 537,720	0.7	$—204,983	— 0.3	$4,513,093	6.0

while at a less rapid rate than that for certain other items, accounted for approximately 60 per cent of the total increase from 1914–15 to 1931–32, and the proportion of the increase chargeable to this item was even greater nine years earlier.

For a true understanding of the change in county expenditures for education it is necessary that the reader keep in mind not only the larger gross population now served by the schools, but also the fact that the average school pupil now carries his training farther in local institutions than was true a decade or more ago. High schools must now serve a much larger proportion than formerly of the pupils of school age, and in many counties junior colleges have been provided. These furnish a type of training that was not previously available locally.

Items or groups of expenditures other than for education have individually been responsible for but a relatively small part of the increase

in all expenditures over those of 1914–15. The increase in highway expenditure during the years following the World War accounted for about 15 per cent of the increase over 1914–15, but in 1931–32 only about 8 per cent of the total increase could be attributed to this service. As previously indicated, the major share of what was actually a large in-

TOTAL INCREASE IN COUNTY EXPENDITURES IN 54 COUNTIES OVER 1914–15 FOR SELECTED YEARS, AND ITEMS OF EXPENDITURE RESPONSIBLE

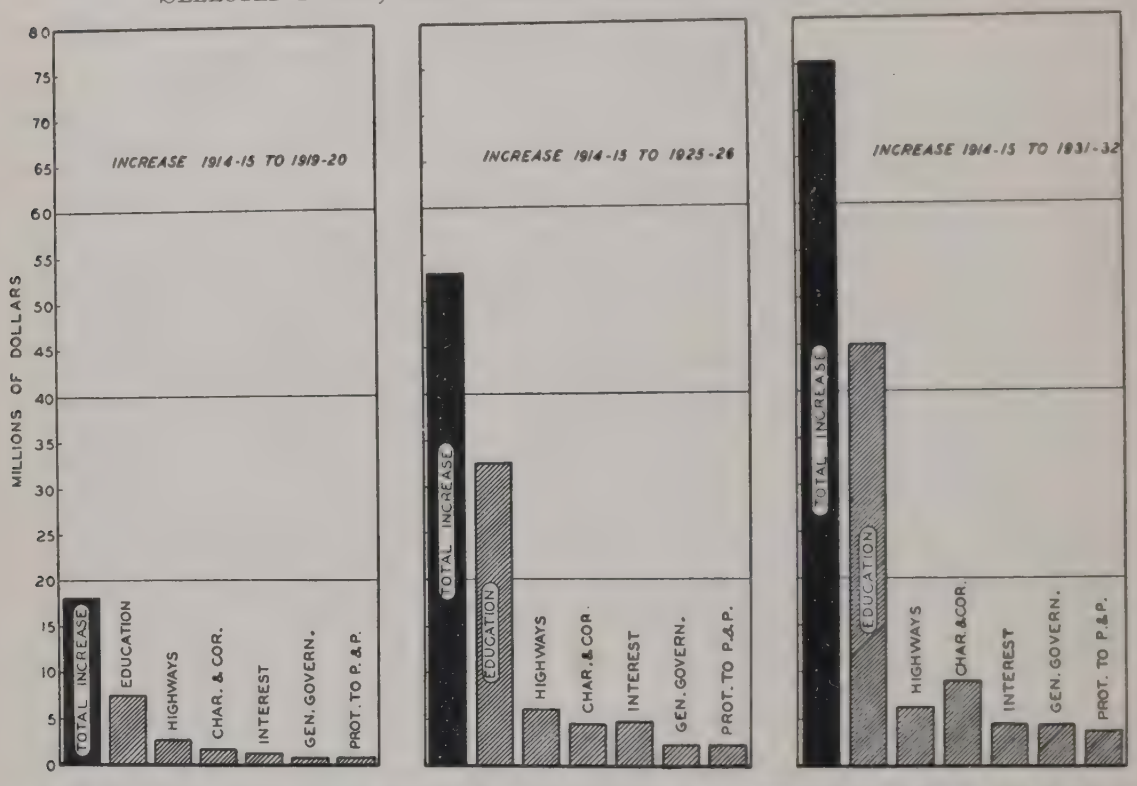


Fig. 9.—The above figure shows the total increase in expenditure from 1914–15 to 1919–20, 1914–15 to 1925–26, and 1914–15 to 1931–32, together with the increase in the individual items of expenditure which accounted for the total increase. (Data from table 6.)

crease in highway expenditure fell not upon the county but upon the state. The increase in expenditure for charities and corrections brought the total increase over 1914–15, explained by the increase in this item, to 12.2 per cent in 1931–32 as compared with 8.4 per cent in 1924–25. At the present time this item ranks second to education in the proportion of the total increase which it explains, although there is perhaps more danger of overestimating than underestimating the part which it has played in the general increase in county expenditure.

The influence which increased expenditure for general government has had upon the total increase has also been overestimated in many quarters. Increased expenditures for maintaining the central core of county organization account for less than 6 per cent of the total increase from 1914–15 to 1931–32 and for less than 4 per cent of the total increase

from 1914–15 to 1922–23. As indicated on page 20 this is not meant to imply that there has been a high, or any particular degree of efficiency in county administration, but rather that there is need for balanced emphasis in considering expenditures along various lines. In contrast to the unthinking charge that elected officials have been the personal beneficiaries of the increase in county expenditure, it is to be noted that had there been no increase whatever since 1914–15 in the branch of county government which supports the majority of elected officials, the increase in expenditure would have been but 6 per cent less to 1931–32.

The services of law enforcement and punishment of criminals together with the variety of activities devoted to the economic welfare of the county, which are all grouped under protection to persons and property, are responsible for approximately 5 per cent of the total increase in county expenditure from 1914–15 to 1931–32. Like the expenditure for charities and corrections, and for general government, the proportion of the total increase for which these activities are accountable has increased from the early twenties. Taken by itself, however, the increase in this item has played a relatively small part in the total increase.

Despite the rapidity of the increase in expenditure for protection of health and for recreation, these items, because of their small absolute amounts, have not contributed markedly to the general increase. The proportion of the increase from 1914–15 to 1931–32 chargeable to recreation was less than 1 per cent; the proportion chargeable to health and sanitation, although greater, was but 2.4 per cent.

In the years following the War the rapid increase in expenditure for interest on indebtedness brought this item to the point where it accounted for approximately 8 per cent of the total increase from 1914–15 to 1922–23. Expenditure for interest on indebtedness in the latter year was $4,254,960 in excess of the 1914–15 level. By 1931–32, however, the increase over 1914–15 was but $250,000 greater than for 1922–23, and with the general upward movement in other expenditures the proportion of the total increase over 1914–15 chargeable to expenditure for interest had fallen to 6 per cent. It has become customary in recent years to assume rapidly increasing levels of indebtedness on the part of governments. The corollary assumption to this, of course, has been that a considerable part of the increase in governmental expenditures is the result of increasing payments for service on indebtedness. The fixity of levels of governmental expenditure in recent years has been frequently justified by the preponderance of debt service within the total.

In recent years, as previously noted, new indebtedness has scarcely kept pace with maturities. That part of the increase in county expenditure over 1914–15 that is attributable to increased expenditure for inter-

est on indebtedness has not been a large part of the total and has been declining. To argue that the slowness with which expenditures have been adjusted downward in recent years is the result of the dominant position of fixed charges for interest and debt redemption is to rest the case on items comprising approximately 10 per cent of the total expenditures of the counties here considered.[22]

THE PRESENT SITUATION IN COUNTY EXPENDITURES

To this point in the present study counties in the state have been treated as a unit—the removal of the three metropolitan counties representing the only deviation from this policy. Further, various expenditures of the county have been taken together in rather considerable groups with necessarily restricted consideration of the character of component parts. In passing now to a closer scrutiny of present-day county expenditure in California, a somewhat different phase of the study is entered upon. With the shortening of the period of time considered, it becomes possible to scrutinize with more care the variation in expenditure as between different counties, and particularly different groups of counties, in the state. Likewise, it becomes feasible to examine in more detail the character of certain individual items of expenditure which have hitherto been grouped together under "charities and corrections," "general government," "protection to persons and property," and other headings.[23]

A three-year average of expenditure covering the years 1929–30, 1930–31, and 1931–32 has been the chief data resource for this section. The necessity for extending the analysis over a three-year period rests largely in the character of the data, with the need for smoothing out the extraordinary expenditures of certain years. The assumption that a three-year average of county expenditure sufficiently distributes capital disbursements to give a fair representation of the ordinary expenditure situation for the various counties is, of course, purely arbitrary. It has proved, however, a workable and, on the whole, a valid approach. Attention has been drawn to the few cases where the influence of extraordinary expenditure upon the average might lead to erroneous inferences.[24]

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[22] Under conditions prevailing before the summer of 1933 that part of the school expenditure which resulted from the counties' matching of state funds might also properly be regarded as a fixed charge together, of course, with the expenditure of the funds derived from the state. When the argument is intended to include these payments, it rests on a somewhat sounder basis.

[23] Expenditures for redemption of indebtedness have been included in the analysis in this section. See Appendix B, pages 106 to 107.

[24] Further details of the data as they relate to the analysis in this section are discussed in Appendix A, pages 102 to 105.

For the purpose of much of the analysis in this section, California counties have been divided into seven groups on the basis of population. Group limits have been established on the basis of a geometric progression from 5,000. Thus counties in group I have populations (1930

TABLE 7

Classification of California Counties

Counties and groups of counties	Population (1930)	Counties and groups of counties	Population (1930)
Group I, 0-5,000:		Group IV (*Continued*)	
Alpine	241	Siskiyou	25,480
Mono	1,360	San Luis Obispo	29,613
Sierra	2,422	Butte	34,093
Trinity	2,809	Merced	36,748
Mariposa	3,233	Santa Cruz	37,433
Del Norte	4,739		
		Group V, 40,000-80,000:	
Group II, 5,000-10,000:		Solano	40,834
Calaveras	6,008	Marin	41,648
Inyo	6,555	Humboldt	43,233
Lake	7,166	Monterey	53,705
Plumas	7,913	Ventura	54,976
Modoc	8,038	Stanislaus	56,641
El Dorado	8,325	Imperial	60,903
Amador	8,494	Sonoma	62,222
Tuolumne	9,271	Santa Barbara	65,167
		San Mateo	77,405
Group III, 10,000-20,000:		Tulare	77,442
Colusa	10,258	Contra Costa	78,608
Nevada	10,596		
Glenn	10,935	Group VI, 80,000 and over:	
San Benito	11,311	Riverside	81,024
Yuba	11,331	Kern	82,570
Lassen	12,589	San Joaquin	102,940
Tehama	13,866	Orange	118,674
Shasta	13,927	San Bernardino	133,900
Sutter	14,618	Sacramento	141,999
Madera	17,164	Fresno	144,379
		Santa Clara	145,118
Group IV, 20,000-40,000:			
Napa	22,897	Metropolitan group:	
Mendocino	23,505	San Diego	209,659
Yolo	23,644	Alameda	474,883
Placer	24,468	Los Angeles	2,208,492
Kings	25,385		

Source of data:

United States Department of Commerce Bureau of the Census. Fifteenth Census of the United States, 1930. Population. Vol. 1:127-145. 1932.

Census) of less than 5,000; counties in group II populations between 5,000 and 10,000; group III between 10,000 and 20,000; group IV between 20,000 and 40,000; group V between 40,000 and 80,000. Counties with populations in excess of 80,000 comprise group VI, except that Los Angeles, Alameda, and San Diego counties are separated therefrom and carried as the "metropolitan group."

Classification of the counties in the above manner gives a rather even distribution of counties to the various groups. In particular, the lower (and, as will develop, most interesting) population groups are small

CLASSIFICATION OF CALIFORNIA COUNTIES

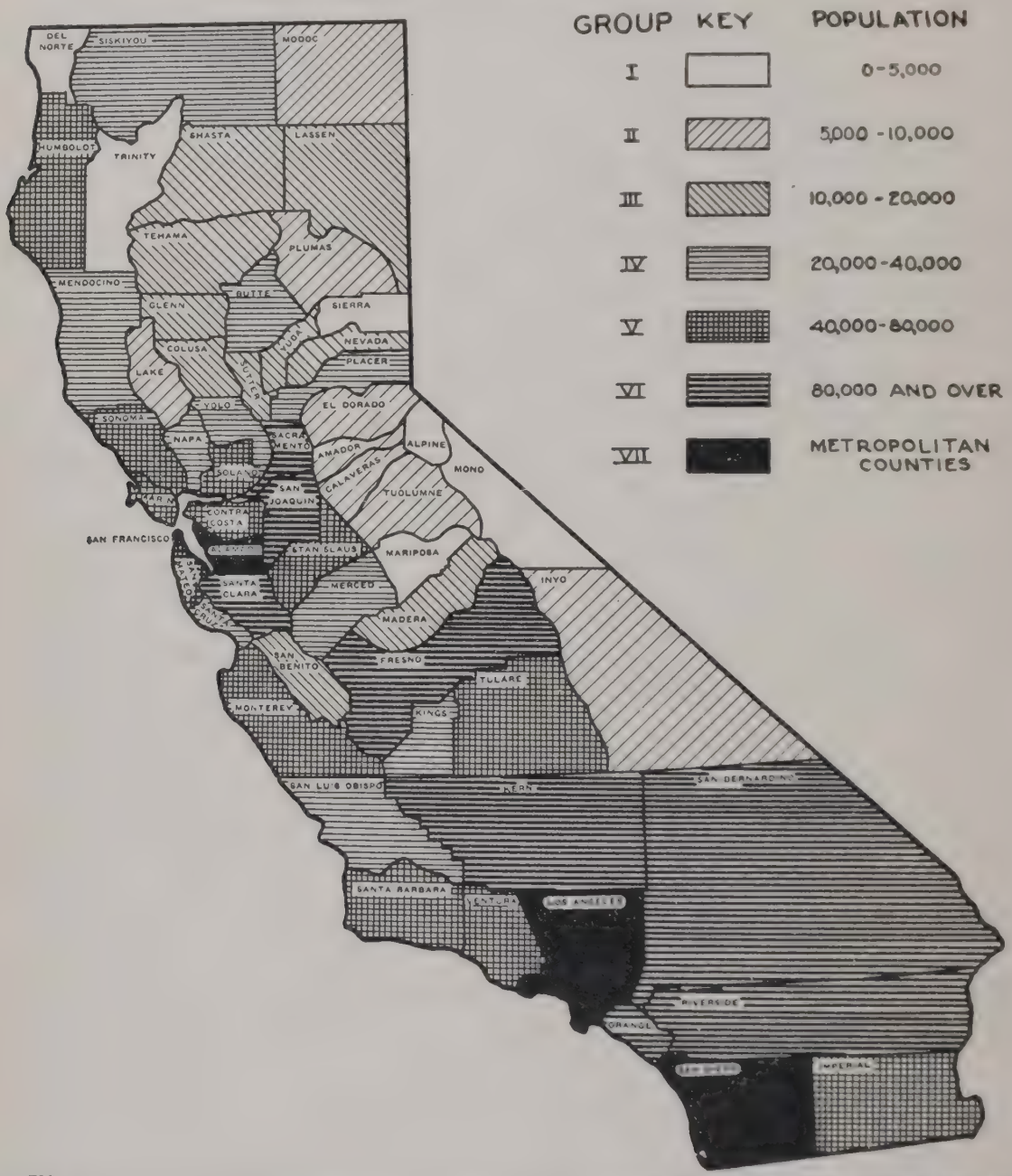


Fig. 10.—For the purposes of this study, California counties have been classified into six groups on the basis of population with a seventh group comprising the metropolitan counties of Los Angeles, Alameda, and San Diego. (Data from table 7.)

enough so that the expenditures of the low-population counties included are thrown into clear relief.

An examination of table 7 and the map (fig. 10) shows that the counties belonging to each of the several groups tend to have more in common than merely the similarity in population which leads to their

being classed together. The six with populations of less than 5,000 are all rather sparsely settled counties, four of them in the Sierra Nevada and two in the Coast Range. All are, of course, mountainous and dependent largely upon mining, lumbering, and recreational resources. Eight counties fall in the group with a population between 5,000 and 10,000, four of them (El Dorado, Amador, Calaveras, and Tuolumne) being contiguous in the foothills of the Sierra Nevada. The counties in this group have some agriculture of importance, although, like the group preceding, they are predominantly mountainous.

In the group of counties with populations between 10,000 and 20,000 are a number of smaller valley counties or counties with a considerable area of arable valley land. Over half of the counties in this group are in the Sacramento Valley or include land on the floor of the Valley.

The next group, with populations between 20,000 and 40,000, is composed, in the main, of larger and more densely populated valley counties together with certain of the larger and more populous Coast Range counties. In the case of the majority of these counties there are sizeable distributing centers which have an appreciable influence on the gross population.

The group with populations of from 40,000 to 80,000 is perhaps the least homogeneous in character. This group includes the first of the southern California counties, together with several coast counties, and Stanislaus and Tulare in the San Joaquin Valley. In almost all of these counties there are cities of some size, while Contra Costa, Marin, and San Mateo have a very considerable urban and semiurban population resident in unincorporated areas.

The counties falling in the group with populations in excess of 80,000 all have one or more of the larger cities of the state within their borders. Fresno, Bakersfield, Santa Ana, Riverside, Sacramento, San Bernardino, San Jose, and Stockton are among the urban centers which contribute to the high ratio of urban to rural population in this group, despite the fact that it includes most of the leading agricultural counties of the state.

In the original plans for the present study, the intention was to attempt an isolation of the relation of population, density of population, ratio of urban to rural population, and possibly topographical character of the county to expenditure distribution and levels by successive grouping of counties on the above bases. The early abandonment of this plan was a result of the comparative similarity of the counties within each group as above outlined. The counties with a low population are also those with a minimum of urban population. With certain exceptions

such as San Bernardino and Riverside,[25] they are also the counties with the lowest density of population and, from the standpoint of topographical character, they are of course, almost exclusively mountain counties. The difficulty of measuring the expenditure differences accompanying each of the above factors is obvious. It has, therefore, been necessary to proceed with a grouping of counties which combined those having in common most of the characteristics which might presumably affect expenditure. This has necessitated placing reliance on qualitative isolation of such of the characteristics of the various classes of counties as may presumably affect their expenditures. It also suggests the danger of too readily assigning causes to differences in expenditure between different groups of counties.

For purposes of comparing levels of expenditure of different counties and groups of counties, extensive reliance has been placed upon per-capita levels of expenditure. This assumes that the county is mainly a unit for performing service to persons and hence the expenditure per person is a valid index of expenditure levels. Education, which is wholly a service to individuals, accounts for approximately one-half of the annual expenditures of the county (page 39 to 42). Expenditures for charities and corrections, health, sanitation, and recreation, bring the total proportion of expenditure solely for indivduals or persons to about 65 per cent. The remaining 35 per cent of the expenditures of the county is for services that are divided in some permanently unknown fashion between individuals and the wealth, or more properly, the economic life of the county. Highways and service on indebtedness make up slightly less than 25 per cent of the remainder. The remaining expenditures, those for general government and for protection to persons and property, making up about 11 per cent of the total, are also divided between individuals and wealth or property. It may be concluded that two-thirds of the services of counties, as measured by expenditure involved, are solely for individuals as well as some unknown but substantial part of the remaining one-third. A per-capita basis for comparing expenditures is hence a reasonably valid basis for comparing the levels of expenditures of different counties.

[25] Another problem in connection with the measuring of density of population is suggested here. While San Bernardino County covers a vast area, the population is relatively concentrated in one corner. No feasible method is apparent for making allowance for such concentration, yet it requires a Pickwickian point of view to assume that the "density" of population in San Bernardino could be arrived at by dividing total population by the total area in square miles.

TOTAL EXPENDITURE

All California counties,[26] during the three years from 1929–30 to 1931–32, expended an average of $269,033,583 annually, the amount varying for individual counties from $53,515 for Alpine to $119,350,558 for Los Angeles. In table 8 the distribution of the total expenditure between the major functions of county government during this period is

TABLE 8

County Expenditure, Distribution and Per-Capita Levels, Major Functions, Average Annual 1929–30 to 1931–32

Item	54 counties			All counties*		
	Amount	Per cent of total	Per capita	Amount	Per cent of total	Per capita
Education	$ 60,012,099	50.3	$27.91	$137,913,065	51.3	$27.35
Highways	17,627,562	14.8	8.20	28,386,965	10.6	5.63
Charities and corrections	10,154,835	8.5	4.72	29,546,488	11.0	5.86
General government	9,063,569	7.6	4.22	19,051,496	7.1	3.78
Protection to persons and property	5,533,551	4.6	2.57	13,153,990	4.9	2.61
Health and sanitation	1,935,074	1.6	0.90	5,007,561	1.9	0.99
Recreation	737,830	0.6	0.34	2,178,372	0.8	0.43
Miscellaneous	1,406,362	1.2	0.65	4,064,919	1.5	0.81
Interest payments	5,952,425	5.0	2.77	15,352,980	5.7	3.04
Redemption of debt	6,820,061	5.7	3.17	14,377,747	5.4	2.85
Total	$119,243,368	100.0	$55.46	$269,033,583	100.0	$53.35

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

summarized. Education, as indicated by the earlier analysis, accounted for slightly over half of the total in all counties and likewise in the 54 counties exclusive of Los Angeles, Alameda, and San Diego. For the remaining 50 per cent, highways is the largest single item of expenditure for the 54 counties, although slightly exceeded by charities and corrections when all counties are considered. General government and protection to persons and property absorbed smaller and roughly similar amounts. The item of service on indebtedness (i.e., combining interest and payments on indebtedness) occupies a significant position in the annual outlay, accounting for 10.7 per cent of the total expenditure for the 54 counties and a slightly larger proportion for all counties combined.

[26] Excluding, of course, the City and County of San Francisco. See Appendix B, page 107.

Several things become apparent from an examination of the total and comparative levels of expenditure for the various counties and county groups (table 9). The large proportion of all county expenditures

TABLE 9

AMOUNT AND PER-CAPITA LEVELS OF TOTAL EXPENDITURE BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per capita	Counties and groups of counties	Amount	Per capita
Group I, 0-5,000	$1,152,524	$ 77.85	GROUP IV (*Continued*)		
Alpine	53,515	222.05	Butte	$ 2,008,698	$58.92
Mono	102,534	75.39	Merced	2,312,619	62.93
Sierra	156,181	64.48	Santa Cruz	1,815,945	48.51
Trinity	182,646	65.02			
Mariposa	217,288	67.21	Group V, 40,000-80,000	39,349,688	55.21
Del Norte	440,360	92.92	Solano	1,675,508	41.03
			Marin	2,140,798	51.40
Group II, 5,000-10,000	3,703,139	59.95	Humboldt	2,394,084	55.38
Calaveras	374,494	62.33	Monterey	3,510,248	65.36
Inyo	444,278	67.78	Ventura	3,953,264	71.91
Lake	529,239	73.85	Stanislaus	2,903,628	51.26
Plumas	542,996	68.62	Imperial	2,601,740	42.72
Modoc	496,516	61.77	Sonoma	3,000,979	48.23
El Dorado	452,804	54.39	Santa Barbara	4,687,807	71.94
Amador	331,379	39.01	San Mateo	3,745,992	48.39
Tuolumne	531,433	57.32	Tulare	3,969,967	51.26
			Contra Costa	4,765,673	60.63
Group III, 10,000-20,000	8,136,800	64.27			
Colusa	883,373	86.12	Group VI, 80,000 and over	51,123,093	53.78
Nevada	429,177	40.50	Riverside	4,285,722	52.89
Glenn	860,174	78.66	Kern	6,621,810	80.20
San Benito	610,514	53.98	San Joaquin	5,206,934	50.58
Yuba	816,380	72.05	Orange	8,126,712	68.48
Lassen	740,600	58.83	San Bernardino	6,293,049	47.00
Tehama	826,463	59.60	Sacramento	6,108,215	43.02
Shasta	847,290	60.84	Fresno	7,494,749	51.91
Sutter	1,109,254	75.88	Santa Clara	6,985,902	48.14
Madera	1,013,575	59.05			
			Total, 54 counties	119,242,799	55.47
Group IV, 20,000-40,000	15,777,555	55.70			
Napa	1,063,094	46.43	Metropolitan group	149,790,785	51.78
Mendocino	1,319,692	56.15	San Diego	10,454,482	49.86
Yolo	1,440,425	60.92	Alameda	19,985,745	42.09
Placer	1,087,688	44.45	Los Angeles	119,350,558	54.04
Kings	1,401,676	55.22			
Siskiyou	1,210,839	47.52	Total, all counties*	$269,033,584	$53.35
San Luis Obispo	$ 2,116,879	$ 71.48			

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

disbursed by the larger counties of the state is worthy of passing comment. By combining the average expenditure of the three metropolitan counties with those in group VI having a population of 80,000 and over, it is to be noted that these 11 counties spend an annual total of $200,913,878 or but slightly less than 75 per cent of the total county expenditure

—a fact which cannot be separated, of course, from the parallel consideration that these counties contain an even greater percentage (76.2)

COMPARATIVE PER-CAPITA EXPENDITURES OF GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

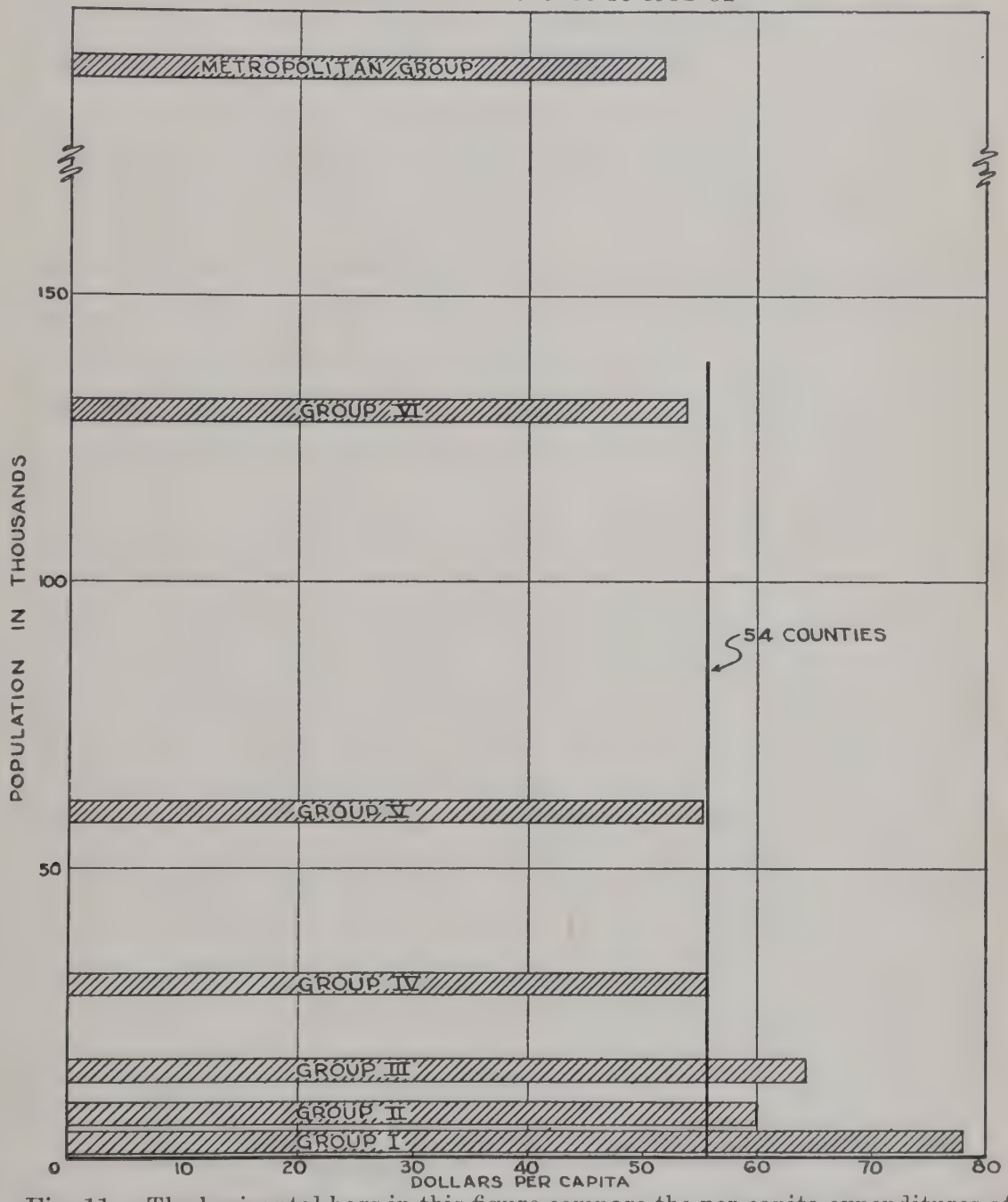


Fig. 11.—The horizontal bars in this figure compare the per-capita expenditures of California counties taken by groups on the basis of population. The bars are spaced apart along the vertical scale so as to indicate the population of the group of counties represented. Thus, the bar marked "group I" shows the per-capita expenditure of counties with populations below 5,000; the one marked "group II," counties with populations between 5,000 and 10,000. (Data from table 9.)

of the population of the state.[27] The concentration in volume of expenditure is somewhat less marked when the metropolitan counties are excluded, although the 20 counties with a population in excess of

[27] Excluding San Francisco.

40,000 spend annually $90,472,781 or 76 per cent of the total for the 54 counties. This group contains 77 per cent of the population of the 54 counties.

The above figures indicate that there is not an immediate correspondence between population and total expenditure levels, and this fact is brought forth in striking fashion by examination of comparative or per-capita levels of expenditure for the different counties and groups of counties (table 9 and figure 11). The per-capita level of expenditure for all counties for the three years under consideration averaged $53.35 and for the 54 counties, $55.47. In contrast with these figures the combined expenditures for the 6 counties with populations of less than 5,000 amounted to $77.85 per capita for the 14,804 people residing therein. Passing over the arresting, if unenviable, record of Alpine with a per-capita outlay of $222.05, it is to be noted that Del Norte, the most populous of this group, had a per-capita average of $92.92 during the three years under consideration, as compared with $55.47 for the 54 counties combined. Sierra County, which had the lowest per-capita expenditure in this group, was still $9.00 above the 54-county level.

For the 8 counties in group II with populations from 5,000 to 10,000 the per-capita level is lower than that of group I by approximately $18.00 or 23 per cent, bringing the group per capita well below that of the lowest county in group I, although still considerably above the 54 and all-county per capita. Closer examination of the individual county figures in this group shows, however, that the lowering of the group per capita is unduly influenced by the level for Amador, the second largest county, with a per-capita expenditure of less than $40.00. Elimination of the population and expenditure of this county from the group results in a per-capita level of slightly over $63.00, or a drop from group I of 20 per cent.

The counties with populations of from 10,000 to 20,000, while showing considerable dispersion in per-capita levels, do not partake of the downward trend in comparative expenditure as a group. Compared with the preceding group, including Amador County, group III has a markedly higher per-capita level of expenditure, while with Amador excluded from the preceding group the two are approximately the same.

The second major decline in per-capita levels of expenditure is to be noted in passing from group III to group IV, the latter including counties with populations of from 20,000 to 40,000. Group IV shows a decline of 13 per cent as compared with group III and from this point on there is a distinct leveling out in per-capita levels of expenditures. Group V, comprising counties with populations of from 40,000 to 80,000, shows a per-capita level approximating that of group IV. Counties falling in

group VI, with populations in excess of 80,000, show some decline in per-capita expenditure as a group although it is markedly less than that occurring between the groups of smaller counties. Lowest in per-capita total expenditure as a group are the three metropolitan counties with an annual outlay of $51.18 per resident, or 30 per cent less than that of the smaller counties of group I.[28]

There is considerable temptation to draw some conclusions at this time from the view of comparative levels of expenditure as just taken. Granting that the major portion of the county expenditures is devoted to the service of persons (page 34), it is apparent that there is a widely varying cost of performing these services on a per-person basis and that the smaller counties are definitely operating at higher expenditure levels than the larger. Before drawing further conclusions, however, it is necessary that the variation between counties in individual items of expenditure be examined in more detail.

EXPENDITURE FOR EDUCATION

All counties for the period under consideration expended an average of $137,913,065 for education. The 54 counties devoted an average of $60,012,099 to this service. In each case educational expenditure amounted to approximately half of the total expenditure (table 8). Elementary school expenditure, including of course school district expenditure (page 105), comprised in turn about half (49.5 per cent) of the total educational expenditure for all counties, with high schools taking 45.3 per cent of the remaining 50.5 per cent (table 10). The 54 counties devoted approximately 51 per cent to elementary schools and 43.2 per cent—a slightly lower proportion than for all counties combined—to the support of high schools. The remaining 5.2 per cent in the case of all counties, and 5.7 per cent in the case of the 54 counties is expended for the support of junior colleges, the county library, super-

[28] It is in keeping with good scientific practice that attention be drawn to the degree of significance of the average employed over the three years. Naturally, there was some variation in the total levels of expenditure—and consequently in the per-capita figures—between the three years, as indicated by the following data for the individual years in question in comparison with the three-year average.

Year	I	II	III	IV	V	VI	Metropolitan
1929–30	$81.76	$59.62	$62.25	$55.03	$52.39	$50.66	$51.25
1930–31	89.90	63.71	67.37	57.53	57.95	56.56	52.86
1931–32	70.89	56.52	63.20	54.52	55.29	54.12	51.21
1929–30 to 1931–32	$77.85	$59.95	$64.27	$55.70	$55.21	$53.78	$51.78

It will be noticed that in each group the movement of the expenditure is in the same direction for the different groups, viz. an increase in 1930–31 and a decrease in 1931–32. In no year is there a material alteration of the broader relations between groups as shown by the average. However, in the case of groups IV and V the per-capita expenditure of the latter was actually a shade higher in two of the three years although a few cents lower in the average.

TABLE 10

AMOUNT, PER CENT OF ALL EXPENDITURES, AND PER-CAPITA LEVELS OF EXPENDITURE FOR EDUCATION BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per cent of all expenditures	Per capita	Counties and groups of counties	Amount	Per cent of all expenditures	Per capita
Group I, 0-5,000	$ 487,389	42.3	$32.92	Group IV (*Cont.*)			
Alpine	10,906	20.4	45.25	Butte	$ 891,891	44.4	26.16
Mono	28,642	27.9	21.06	Merced	1,044,093	45.1	28.41
Sierra	69,469	44.5	28.68	Santa Cruz	934,252	51.4	24.95
Trinity	69,025	37.8	24.57				
Mariposa	102,245	47.1	31.62	Group V, 40,000-80,000	19,264,394	49.0	27.03
Del Norte	207,102	47.0	43.70	Solano	921,302	55.0	22.56
				Marin	1,000,204	46.7	24.02
Group II, 5,000-10,000	1,729,733	46.7	28.00	Humboldt	978,416	40.9	22.63
Calaveras	161,936	43.2	26.95	Monterey	1,536,763	43.8	28.61
Inyo	208,421	46.9	31.80	Ventura	1,620,202	41.0	29.47
Lake	261,112	49.3	36.44	Stanislaus	1,623,097	55.9	28.66
Plumas	236,500	43.6	29.89	Imperial	1,311,953	50.4	21.54
Modoc	252,335	50.8	31.39	Sonoma	1,415,883	47.2	22.76
El Dorado	195,797	43.2	23.52	Santa Barbara	2,264,930	48.3	34.76
Amador	186,212	56.2	21.92	San Mateo	2,055,437	54.9	26.55
Tuolumne	227,420	42.8	24.53	Tulare	2,032,972	51.2	26.25
				Contra Costa	2,503,235	52.5	31.84
Group III, 10,000-20,000	3,823,672	47.0	30.20	Group VI, 80,000 and over	27,187,997	53.2	28.60
Colusa	418,734	47.4	40.82	Riverside	1,971,653	46.0	24.33
Nevada	202,471	47.2	19.11	Kern	3,611,844	54.5	43.74
Glenn	377,725	43.9	34.54	San Joaquin	2,272,812	43.6	21.08
San Benito	315,659	51.7	27.91	Orange	4,678,223	57.6	39.42
Yuba	344,977	42.3	27.07	San Bernardino	3,416,249	54.3	25.51
Lassen	359,843	48.6	25.18	Sacramento	3,105,349	50.8	21.87
Tehama	394,030	47.7	29.28	Fresno	4,058,483	54.2	28.11
Shasta	389,625	46.0	26.16	Santa Clara	4,073,384	58.3	28.07
Sutter	466,938	42.1	28.41				
Madera	553,670	54.6	24.95	Total 54 counties	60,012,099	50.3	27.91
Group IV, 20,000-40,000	7,518,914	47.7	26.54	Metropolitan group	77,900,966	52.0	26.93
Napa	498,018	46.8	21.75	San Diego	5,089,925	48.7	24.28
Mendocino	746,012	56.5	31.74	Alameda	10,962,571	54.8	23.08
Yolo	600,086	41.7	25.38	Los Angeles	61,848,470	51.8	28.00
Placer	608,803	56.0	24.88				
Kings	687,195	49.0	27.07				
Siskiyou	641,494	53.0	25.18	Total, all counties*	$137,913,065	51.3	$27.35
San Luis Obispo	$ 867,070	41.0	$29.28				

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

Comparative Per-Capita Expenditure and Proportion of All Expenditures for Education by Groups of California Counties, Average Annual 1929–30 to 1931–32

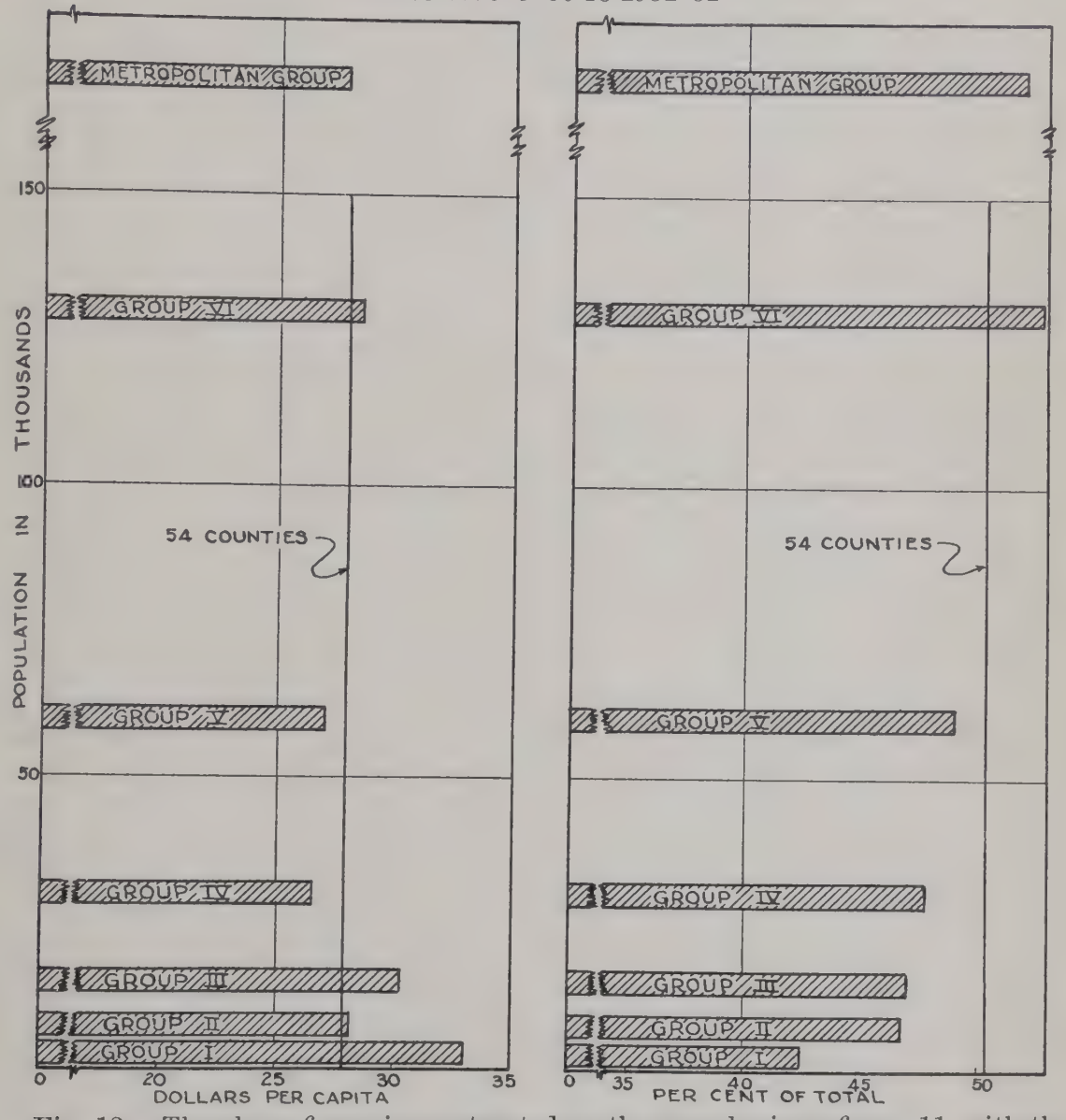


Fig. 12.—The above figure is constructed on the same basis as figure 11, with the right-hand section comparing the proportion of all expenditures devoted to education by counties in the various population groups beginning at the bottom with counties in group I having populations of less than 5,000. (Data from table 10.)

intendent of schools, county board of education, and other expenditures related to the educational system.[29]

While education occupies a major place in the budgets of all counties,[30] its relative position differs considerably as between the larger and

[29] It has been considered that expenditure for education covered a function sufficiently homogeneous in objective that it could be justly treated in unitary fashion in the present study. For this reason no lengthy effort has been made to break educational expenditure into constituent parts in the manner in which several of the much less important, but also much less homogeneous groups have been treated

[30] Highway expenditure exceeds educational expenditure in Alpine and Mono, and expenditure for general government is approximately equal to that for education in the case of the former.

smaller counties (table 10 and fig. 12). For the 54 counties, education accounts for 50.3 per cent of the total expenditure, but the group of counties with populations of less than 5,000 expend but 42.3 per cent of their annual total for this function. In passing from the smaller to the larger population groups, a gradual but steady increase in the proportion of annual expenditures is devoted to education. Counties with populations of from 5,000 to 10,000 spend 46.7 per cent of their annual total for this function, while those with populations of 10,000 to 20,000 spend 47.0 per cent. Further increases in the percentage of all expenditures devoted to education are noted for groups IV, V, and VI, while the metropolitan counties spend 52.0 per cent of all expenditures for this function.

From the above data it might appear at first glance that the smaller counties were obtaining educational services in such fashion as to entail a less severe strain on their aggregate budget than in the case of the larger counties. Examination of the per-capita levels of expenditure for education (table 10 and fig. 12), however, serves to correct this impression. Despite the smaller part played by educational services in the expenditure total, per-capita costs of education are as high as those for the large counties, and, in the case of the very low population groups, higher. The three-year average per-capita expenditure for education for the 54 counties amounted to $27.91, while the 6 counties, with populations of less than 5,000, expended $32.92 or $5.01 per capita in excess of that expended by the 54 counties. Per-capita expenditure for group II was not significantly above that for the 54 counties, but the 10 counties with populations of from 10,000 to 20,000 expended $30.20 per capita or $2.29 more than the general level.

The service of education is categorically a service to persons, and the levels of per-capita expenditure are hence a rather precise basis of comparison of levels of expenditure for this service. Unless there is a higher proportion of the total population in the lower or school-age brackets in the smaller counties, which census data show to be not the case,[31] it may thus be concluded that while the smaller counties of the state choose (or are forced) to allot a smaller proportion of their annual budget to

[31] Census data actually show an increasing ratio of children in attendance at schools in passing from the smaller population groups to the larger, with the exception of the metropolitan counties. Children from seven to thirteen years of age in attendance at schools were 10.40 per cent of the population for group I and 10.66 per cent of the population for group II, as contrasted with 12.51 per cent, 12.24 per cent, and 12.42 per cent for groups III, IV, and V, respectively. The same general trend occurs for children of fourteen and fifteen years of age, and the larger percentage of children in school to total population for the high-school-age bracket of sixteen and seventeen years in the larger counties is especially apparent. (Data from: United States Department of Commerce Bureau of the Census. Fifteenth Census of the United States, 1930. Population. Vol. 1:127–145. 1932.)

education, the comparative expenditure on the basis of individuals served is actually higher than in the case of the larger counties. This latter of course implies the further questions whether the necessary cost of providing education in the sparsely populated mountain counties is greater than that in the densely populated area, and whether the standards of service are comparable in the smaller and larger counties.

TABLE 11

DIVISION OF COUNTY EXPENDITURE BETWEEN ELEMENTARY AND HIGH SCHOOLS BY COUNTY GROUPS, AVERAGE ANNUAL 1929–30 TO 1931–32

County group	Total expenditure for education	Elementary schools			High schools		
		Expenditure	Per capita	Per cent of total for education	Expenditure	Per capita	Per cent of total for education
Group I	$ 487,389	$ 312,260	$21.09	64.1	$ 155,650	$10.51	31.9
Group II	1,729,733	883,151	14.30	51.1	748,797	12.12	43.3
Group III	3,823,672	1,926,788	15.22	50.4	1,630,880	12.88	42.7
Group IV	7,518,914	3,964,564	14.00	52.7	3,205,922	11.32	42.6
Group V	19,264,394	9,911,299	13.90	51.4	8,085,045	11.34	42.0
Group VI	27,187,997	13,594,090	14.30	50.0	12,069,973	12.70	44.4
54 counties	60,019,099	30,592,152	14.20	51.0	25,896,267	12.00	43.1
Metropolitan group	77,900,966	37,676,707	13.02	48.4	36,536,237	12.53	46.9
All counties*	$137,913,065	$68,268,859	$13.54	49.5	$62,432,504	$12.38	45.3

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

The above are questions which bear strongly upon the problem of justifiability of the expenditure situation as it exists but which are not wholly germane to an objective examination of the expenditure situation as it is. That there are higher costs in taking education to a scattered population with virtually individual tutelage for the few children of the district has been fairly generally recognized. These are not costs, however, which can be isolated on the basis of present data.

An examination of the distribution of educational expenditure between elementary and high schools for the various county groups (table 11) indicates that in extent of educational facilities, as shown by provision of secondary education, there is a definite tendency for the very small counties to lag behind the more populous units. Counties in group I with populations of less than 5,000 devoted 64 per cent of their educational expenditure to elementary schools as against 32 per cent to high schools. This is in contrast with 51 per cent for elementary schools and 43 per cent for high schools by the 54 counties combined. In the case of group I it is especially significant that, despite the highest per-capita expenditure for education in general and much the highest per-

capita expenditure for elementary schools, this group had the lowest per-capita expenditure for high schools, which is indicative of a very considerable deficiency in the latter regard as compared with the more populous counties. As to the quality of the educational services—beyond the mere matter of high-school facilities—the bases for judgment are limited. As measured by conventional standards of educational performance, serious shortcomings are generally noted in the schools of areas such as those comprising the smaller counties of the state. The extent of such deficiencies cannot, however, be measured.

EXPENDITURE FOR HIGHWAYS

Despite the lessening of the counties' share in road-building activities since 1921, highway and highway structures continued to occupy second place in importance for the large majority of counties during the three years under consideration. Expenditure for highways by the 54 counties amounted to an annual average of $17,627,562 (table 12) during this period and accounted for 14.8 per cent of the total expenditure. For all counties the highway expenditure was $28,386,965 or 10.6 per cent of the expenditure total. Inclusion of the three metropolitan counties with 7.2 per cent of their total expenditure for highways as against 12.9 for charities and corrections brings the all-county expenditure for the latter service slightly over that for highways.

Even the most cursory examination of table 12 and figure 13 shows the markedly different position occupied by highway expenditure in the budgets of the large and small counties. Beginning with Alpine County (which usually serves to depict the extreme in any trend from smaller to larger counties) with 48 per cent of its total expenditure for highways, there is a somewhat irregular but entirely unmistakable decline in the relative importance of this item until, in the case of Alameda and Los Angeles counties, it accounts for less than 7 per cent of the total.[32] The small counties in group I devote the highest proportion of their expenditures to the building and maintaining of roads. The average annual outlay of these counties for this service over the three years considered amounts to 21.7 per cent, or slightly over one-fifth of their total expenditures, as against slightly less than 15 per cent for the 54 counties as a whole. The proportion of total expenditure for highways remains at a similar level for counties with populations falling between 5,000 and 10,000, with a significant drop to 16.9 per cent of the total, or 2 per cent over the 54-county level, for the counties in group III with populations of from 10,000 to 20,000.

[32] However, see page 47 for other factors of importance in the case of these latter counties.

A significant, although not all-important, reason for the decline in the importance of highway expenditure between groups I and II and

TABLE 12

AMOUNT, PER CENT OF ALL EXPENDITURES, AND PER-CAPITA LEVELS OF EXPENDITURE FOR HIGHWAYS BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per cent of all expenditures	Per capita	Counties and groups of counties	Amount	Per cent of all expenditures	Per capita
Group I, 0-5,000	$ 249,528	21.7	$ 16.85	Group IV (*Cont.*)			
Alpine	25,723	48.1	106.73	Butte	$ 416,339	20.7	$12.21
Mono	33,027	32.2	24.28	Merced	318,845	13.8	8.68
Sierra	43,346	27.8	17.90	Santa Cruz	335,391	18.5	8.96
Trinity	39,153	21.4	13.94				
Mariposa	49,307	22.7	15.25	Group V, 40,000-80,000	6,217,174	15.8	8.72
Del Norte	58,972	13.4	12.44	Solano	210,326	12.6	5.15
				Marin	452,640	21.1	10.87
Group II, 5,000-10,000	755,435	20.4	12.23	Humboldt	470,168	19.6	10.88
Calaveras	88,211	23.6	14.68	Monterey	1,033,486	29.4	19.24
Inyo	77,552	17.5	11.83	Ventura	719,671	18.2	13.09
Lake	92,951	17.6	12.97	Stanislaus	343,470	11.8	6.06
Plumas	186,314	34.3	23.55	Imperial	308,195	11.8	5.06
Modoc	57,615	11.6	7.17	Sonoma	633,489	21.1	10.18
El Dorado	92,331	20.4	11.09	Santa Barbara	554,357	11.8	8.51
Amador	43,161	13.0	5.08	San Mateo	348,092	9.3	4.50
Tuolumne	117,300	22.1	12.65	Tulare	538,994	13.6	6.96
				Contra Costa	604,286	12.7	7.69
Group III, 10,000-20,000	1,376,394	16.9	10.87	Group VI, 80,000 and over	6,354,037	12.4	6.68
Colusa	135,685	15.4	13.23	Riverside	596,801	13.9	7.37
Nevada	63,170	14.7	5.96	Kern	699,824	10.6	8.47
Glenn	154,644	18.0	14.14	San Joaquin	874,517	16.8	8.50
San Benito	115,300	18.9	10.19	Orange	1,335,564	16.4	11.25
Yuba	146,059	17.9	12.89	San Bernardino	776,788	12.3	5.80
Lassen	135,268	18.3	10.74	Sacramento	498,217	8.2	3.51
Tehama	124,725	15.1	9.00	Fresno	807,858	10.8	5.60
Shasta	136,138	16.1	9.78	Santa Clara	764,468	10.9	5.27
Sutter	241,452	21.8	16.52				
Madera	123,953	12.2	7.22	Total, 54 counties	17,627,562	14.8	8.20
Group IV, 20,000-40,000	2,674,994	17.0	9.44	Metropolitan group	10,759,403	7.2	3.72
Napa	196,540	18.5	8.58	San Diego	1,193,782	11.4	5.69
Mendocino	245,238	18.6	10.43	Alameda	1,367,038	6.8	2.88
Yolo	338,415	23.5	14.31	Los Angeles	8,198,583	6.9	3.71
Placer	110,435	10.2	4.51				
Kings	231,930	16.5	9.14				
Siskiyou	211,364	17.5	8.29	Total, all counties*	$28,386,965	10.6	$ 5.63
San Luis Obispo	$ 270,497	12.8	$ 9.13				

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

group III is to be gleaned from a consideration of the topographical character of the counties comprising these groups. Groups I and II contain the majority of the wholly or predominantly mountainous

counties of the state, while in group III a number of the smaller valley counties appear. Both the need for road facilities and the increased cost of making provision for them in the mountain areas are undoubtedly

COMPARATIVE PER-CAPITA EXPENDITURE AND PROPORTION OF ALL EXPENDITURES FOR HIGHWAYS BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

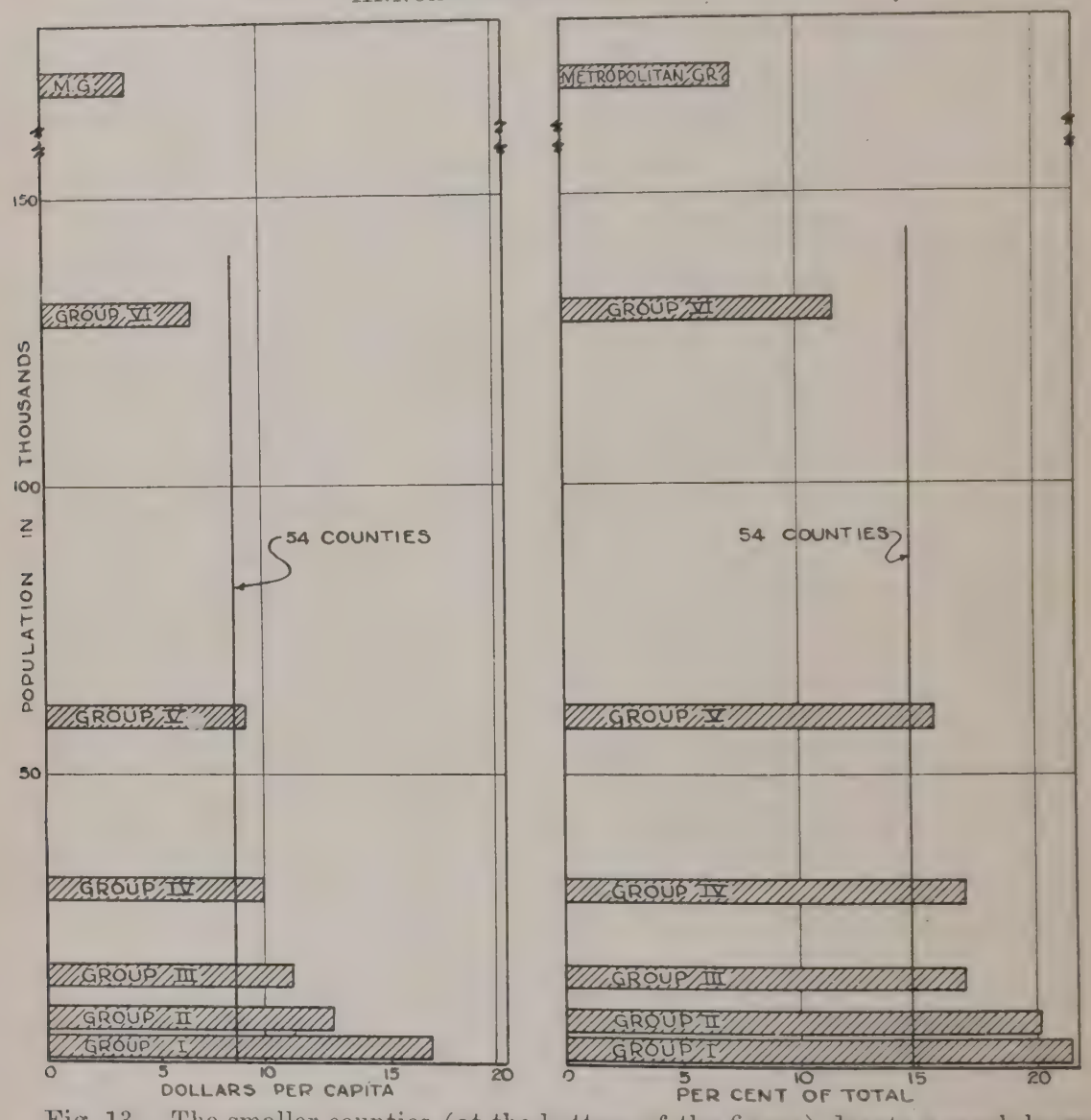


Fig. 13.—The smaller counties (at the bottom of the figure) devote a much larger proportion of their total expenditures to the construction and maintenance of highways than do the larger counties. Likewise the per-capita levels of expenditure for this item are much higher in the smaller counties. (Data from table 12.)

reflected in a higher proportion of the expenditure for this item in the counties of this character.[33]

Little change is seen in the proportion of total expenditures devoted to road construction in passing from group III to group IV, but beyond this latter group there is a steady decline in the proportion of the total

[33] However, see pages 47 and 48 for other factors of importance in making for a higher road expenditure by the smaller counties.

devoted to this service. Counties falling in group V, with populations from 40,000 to 80,000, expended 15.8 per cent of their collective total for highways, while those with populations in excess of 80,000 expended 12.4 per cent of the total. Counties falling in the metropolitan group showed by far the smallest proportion of their expenditure for highways, this service falling to the relatively minor place of 7.2 per cent of the total budget.

Besides the greater difficulty of providing highway facilities in the smaller mountainous counties, three other factors worthy of mention contribute to the differences in importance of highway expenditures as between large and small counties. In the case of the larger counties the greater population and, in most cases, greater density of population unquestionably tend to increase the efficiency of highway use. Even with the provision of better roads in such counties, unquestionably a greater quantity of use per unit of investment and consequently a smaller relative burden for this function in comparison with other services occurs with the larger number of people served.

The second element in the lower percentage of all expenditure for highways, on the part of the larger counties, is the displacement of the county by other road-building units of government. In the case of the three metropolitan counties and, in lesser degree, in the case of certain of the counties in group VI, the burden of a significant share of the road-building and maintenance falls upon municipalities in the form of street construction and upkeep. There seems little doubt but that the low percentage of the total expenditures for highways on the part of Los Angeles and Alameda counties lies in this situation. While less susceptible to proof, there also seems to be some possibility that the highway programs of the state have dealt more favorably with the larger counties than the smaller. Necessarily, a complete through system of highways taps and traverses first the more populous areas. Counties of sparse population are served in the early stages of construction only in an incidental way as they happen to be traversed by such routes. In the case of California, few of the counties in the smaller population groups are located on the main arteries of travel between the urban centers of the state. Through highways, of course, displace an equivalent or more than equivalent mileage of locally maintained highway with consequent reduction in the expenditure budget for this item by the county unit. While the expansion of the state highway system tends to gradually remove the advantage of the more fortunately located counties, there is a strong possibility that it is still reflected in their lower expenditure for this item.

A final factor which later analysis shows to have an influence on the

varying place of highway expenditure in the county budget is that of the size of the administrative unit. The statutory division of the county into five supervisorial road districts undoubtedly reduces the latter in the smaller counties below the size where road-building and maintenance operations can be handled with maximum economy. This is particularly true in a day when road-engineering has developed a high degree of mechanical efficiency involving the use of expensive machinery. The small unit must, under such circumstances, lag behind with obsolete and, hence, costly methods or invest in equipment which it is incapable of using to capacity. In either case its expenditure for the provision of a given volume of road service—probably more acutely needed in relation to population and wealth in the small mountain counties than elsewhere—is greatly increased. This is a problem worthy of detailed study in itself.

Also in line with the decreasing importance of highway expenditure in the county budget, in passing from the smaller to the larger counties, is a markedly lower per-capita expenditure for this item in the larger counties (table 12 and fig. 13). As a matter of fact, the comparison of per-capita expenditure for highways, reflecting the higher per-capita levels of all expenditure for the smaller counties, presents more striking contrasts than the proportion of the total budget devoted to this service in the various county groups. Counties in group I expended a per-capita average of $16.85 for the three years under consideration as compared with $8.20 or less than half of that amount by the 54 counties combined. Whereas counties in group II allotted but a slightly smaller percentage of their total budget to highways than counties in group I, the per-capita expenditure was $12.23 or $4.62 less than that of the group of smaller counties. Further decreases occur in the per-capita levels of road expenditure for succeeding groups until for group V, comprising counties with populations of from 40,000 to 80,000, it stands at $8.72, or slightly over half of the per-capita level for group I. For group VI there is a further decline to $6.68 or, in this case, but slightly over half of the expenditure for group II.

While contributing to the general fund of information on highway expenditure and aiding in the orientation of its place in the general expenditure situation, per-capita comparisons of levels of highway expenditure do not have the same significance as in the case of other functions. Unlike education, for example, highways are not entirely or perhaps even in major part a direct service to persons. Nor is the service restricted to the use of the people enumerated in the county. Highways, even though constructed or maintained by a given unit, are instead a cosmopolitan possession of a community larger than that re-

sponsible for their construction. For these reasons per-capita figures are not significant indexes of comparative levels of outlay in terms of extent of service performed. Rather they are abstractions which bring incomprehensible magnitudes to comprehensible proportions. The brief discussion of per-capita levels of highway expenditure is inserted here with this viewpoint in mind. Caution should be exercised in any interpretation based on a viewpoint apart from the above.

EXPENDITURES FOR CHARITIES AND CORRECTIONS

Expenditures for charities and corrections for the three-year period amounted to an average of $10,154,835 or 8.5 per cent of the total expenditures for the 54 counties. For all counties the total expenditures for the services grouped under this heading amounted to $29,546,548 or 11.0 per cent of the all-county total. (See table 13.)

As between the large and small counties, this group of expenditures shows an alignment unlike that of any of the other services or groups of services of the county unit. The groups of smaller counties show some tendency to devote a larger proportion of their total resources to this function than do the counties in the intermediate groups. Counties comprising group II devoted 9.0 per cent of their expenditures to charities and corrections, while a low point for all groups is distinguishable with group V where but 7.9 per cent of the total expenditure goes for this group of services. (See table 13 and fig. 14.) For group VI, counties with a population exceeding 80,000, and the metropolitan group there is again a sharp increase in the proportion of total expenditures to 9.4 per cent of the total in the case of the former and to 12.9 per cent in the latter.

Somewhat more illustrative, however, are the figures for comparative or per-capita expenditures, which of course take cognizance of the differences in total levels of expenditure. Counties in group I, on the basis of such comparison, take a commanding lead among the smaller counties with a per-capita expenditure of $6.31. A drop of approximately $0.90 per capita occurs in passing to the next group with a further small decline in group III, which includes counties with populations of from 10,000 to 20,000. Expenditure for this item is substantially lower for counties in group IV, and a minimum of $4.03 is reached in group V, which includes counties with populations between 40,000 and 80,000. As indicated by the proportion of total expenditure devoted to charities and corrections, a marked increase to $5.05 per capita for counties with populations in excess of 80,000 is seen, and in the case of the metropolitan counties it again exceeds that for group I, amounting to $6.70 per capita.

Expenditures for charities and corrections cover the support of a variety of services. Before drawing conclusions about the reasons for

TABLE 13

AMOUNT, PER CENT OF ALL EXPENDITURES, AND PER-CAPITA LEVELS OF EXPENDITURES FOR CHARITIES AND CORRECTIONS BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per cent of all expenditures	Per capita	Counties and groups of counties	Amount	Per cent of all expenditures	Per capita
Group I, 0-5,000	$ 93,378	8.1	$6.31	Group IV (*Cont.*)			
Alpine	250	0.5	1.04	Butte	$ 188,436	9.4	$5 53
Mono	4,804	4.7	3.53	Merced	204,665	8.8	5 57
Sierra	10,173	6.5	4.20	Santa Cruz	101,499	5.6	2.71
Trinity	27,590	15.1	9.82				
Mariposa	21,214	9.8	6.56	Group V, 40,000-			
Del Norte	29,347	6.7	6.19	80,000	2,872,149	7.3	4.03
				Solano	106,574	6.4	2.61
Group II, 5,000-				Marin	126,595	5.9	3 04
10,000	334,796	9.0	5.42	Humboldt	360,307	15.0	8.33
Calaveras	38,346	10.2	6.38	Monterey	164,701	4.7	3.07
Inyo	36,482	8.2	5.57	Ventura	287,471	7.3	5 23
Lake	29,983	5.7	4.18	Stanislaus	271,029	9.3	4 78
Plumas	32,125	5.9	4.06	Imperial	100,942	3.9	1.66
Modoc	34,041	6.9	4.24	Sonoma	244,806	8.2	3.93
El Dorado	56,301	12.4	6.76	Santa Barbara	499,080	10.6	7.66
Amador	43,130	13.0	5.08	San Mateo	125,041	3.3	1.62
Tuolumne	64,390	12.1	6.95	Tulare	266,935	6.7	3.45
				Contra Costa	318,675	6.7	4.05
Group III, 10,000-							
20,000	675,862	8.3	5.34	Group VI, 80,000			
Colusa	88,196	10.0	8.60	and over	4,802,412	9.4	5.05
Nevada	53,891	12.6	5.09	Riverside	355,989	8.3	4.39
Glenn	49,142	5.7	4.49	Kern	390,811	5.9	4.73
San Benito	25,483	4.2	2.25	San Joaquin	684,820	13 2	6 65
Yuba	66,094	8.1	5.83	Orange	364,822	4.5	3.07
Lassen	59,340	8.0	4 71	San Bernardino	500,204	7.9	3.74
Tehama	53,210	6.4	3.84	Sacramento	890,936	14.6	6.29
Shasta	117,183	13.8	8.41	Fresno	687,689	9.2	4.76
Sutter	84,059	7.6	5.75	Santa Clara	927,150	13.3	6.39
Madera	79,264	7.8	4.62				
				Total, 54 counties	10,154,814	8.5	4.72
Group IV, 20,000-							
40,000	1,376,217	8.7	4.86	Metropolitan			
Napa	82,276	7.7	3.59	group	19,391,674	12.9	6 70
Mendocino	73,237	5.5	3.12	San Diego	1,323,595	12.7	6 31
Yolo	113,071	7.8	4.78	Alameda	3,282,249	16 4	6.91
Placer	110,174	10.1	4.50	Los Angeles	14,785,869	12.4	6.70
Kings	128,872	9.2	5.08				
Siskiyou	117,081	9.7	4.60	Total, all counties*	$29,546,488	11 0	$5 86
San Luis Obispo	$ 256,909	12.1	$8.68				

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

the higher expenditures for these services in the very small and in the very large counties, the individual items included in this group should be examined in some detail.

For all counties combined, the expenditure for direct relief together with the much smaller commitments for burial of indigents and other charities constituted the largest item coming under the heading of chari-

COMPARATIVE PER-CAPITA EXPENDITURE AND PROPORTION OF ALL EXPENDITURES FOR CHARITIES AND CORRECTIONS BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

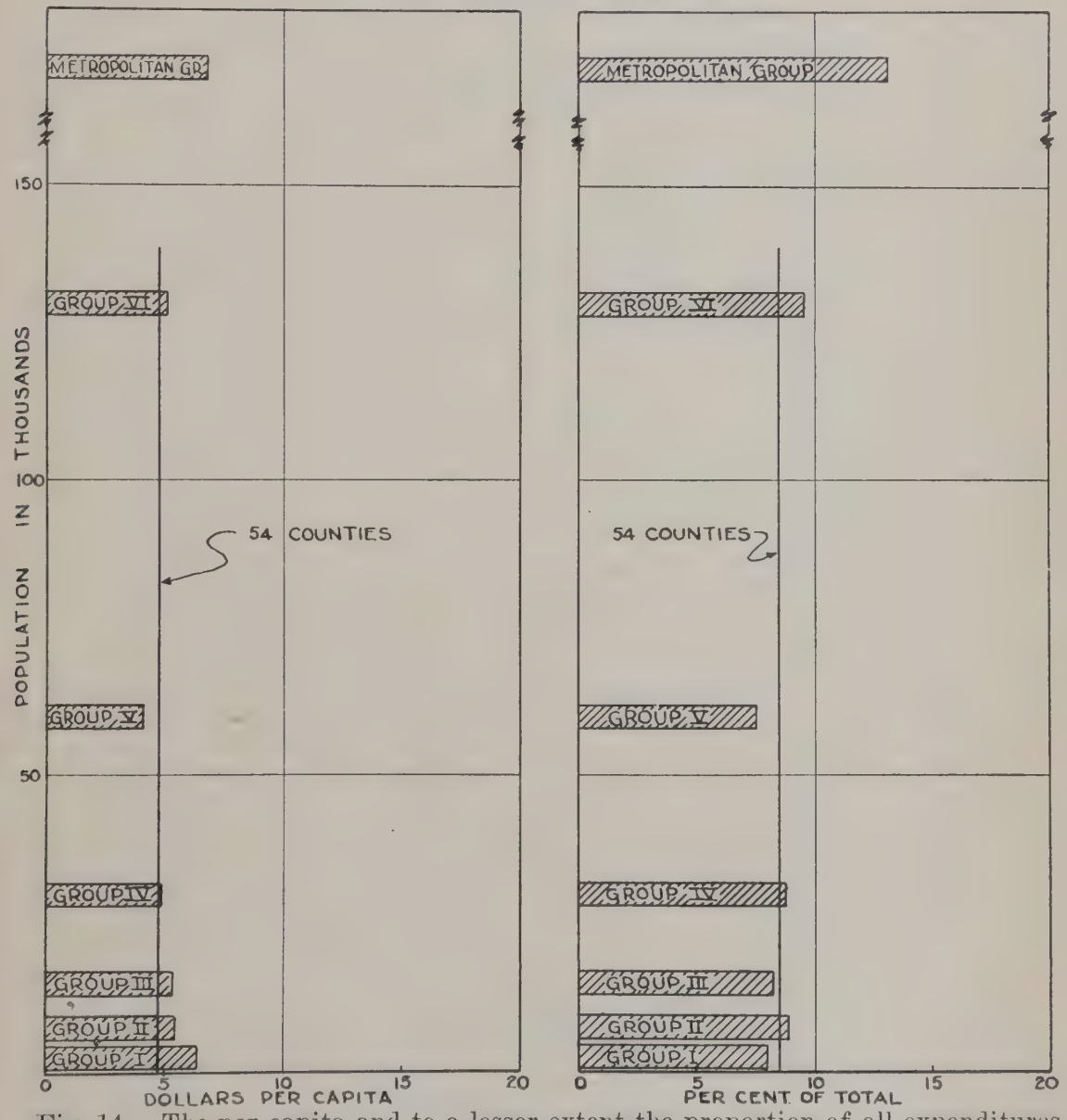


Fig. 14.—The per capita and to a lesser extent the proportion of all expenditures for charities and corrections at first decrease in passing from the smaller counties (at the bottom of the figure) to the larger. When the very populous units are reached, however, there is again a marked increase. (Data from table 13.)

ties and corrections. (See table 14 and fig. 15.) For the 54 counties, however, direct relief and associated items absorbed but 33.1 per cent of the total as compared with 41.6 for maintenance of the county hospital and almshouse.[34] Taken together the two above-mentioned groups make

[34] Expenditure for the county physician, a relatively minor item, is included in the latter because of the apparent failure of some counties to report it separately from the expenditure for maintenance of the hospital and almshouse.

TABLE 14

DETAIL OF EXPENDITURE FOR CHARITIES AND CORRECTIONS BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

County group	County physician, county hospital, and almshouse			Relief of indigents, burial of indigents, and other charities			Care of children, probation officer, care of inmates in reform schools			Care of inmates in homes for feeble minded, care and examination of insane			Outlays		
	Amount	Per cent of total for charities and corrections	Per capita	Amount	Per cent of total for charities and corrections	Per capita	Amount	Per cent of total for charities and corrections	Per capita	Amount	Per cent of total for charities and corrections	Per capita	Amount	Per cent of total for charities and corrections	Per capita
Group I	$ 35,163	37 7	$2 38	$ 45,698	48.9	$3.09	$ 10,693	11.5	$0.72	$ 1,058	1.1	$0 07	$ 766	0 8	$0 05
Group II	109,173	32 6	1 77	147,406	44.0	2.38	64,377	19.2	1.04	5,933	1 8	0 10	7,908	2 4	0 13
Group III	210,544	31 2	1 66	309,380	45.8	2.45	98,783	14.6	0.78	20,183	3 0	0 16	36,971	5 4	0 29
Group IV	507,624	36 9	1 79	548,239	39.8	1.94	226,451	16.5	0.80	31,463	2 3	0 11	62,440	4 5	0 22
Group V	975,302	34 0	1 37	1,017,155	35.4	1 43	500,723	17.4	0.70	97,256	3.4	0.14	281,713	9 8	0 39
Group VI	2,382,797	49 6	2 51	1,289,692	26.9	1.36	626,269	13.0	0.66	119,231	2 5	0.12	384,423	8 0	0 40
54 counties	4,220,603	41 6	1 96	3,357,570	33 1	1 56	1,527,296	15.0	0.71	275,124	2 7	0 13	774,221	7 6	0 36
Metropolitan group	6,339,947	32 7	2 19	7,300,485	37.6	2.52	2,283,738	11 8	0 79	401,037	2 1	0 14	3,066,467	15 8	1 06
All counties*	$10,560,550	35 7	$2 10	$10,658,055	36 1	$2 11	$3,811,034	12 9	$0 76	$676,161	2 3	$0 13	$3,840,688	13 0	$0 76

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

up the great bulk of the expenditure for charities and corrections—in the case of the 54 counties, 74.7 per cent of the total, and for all counties, 71.8 per cent.

COMPARATIVE PER-CAPITA EXPENDITURE FOR VARIOUS CLASSES OF ITEMS INCLUDED UNDER CHARITIES AND CORRECTIONS BY GROUPS OF CALIFORNIA COUNTIES, ANNUAL AVERAGE 1929–30 TO 1931–32

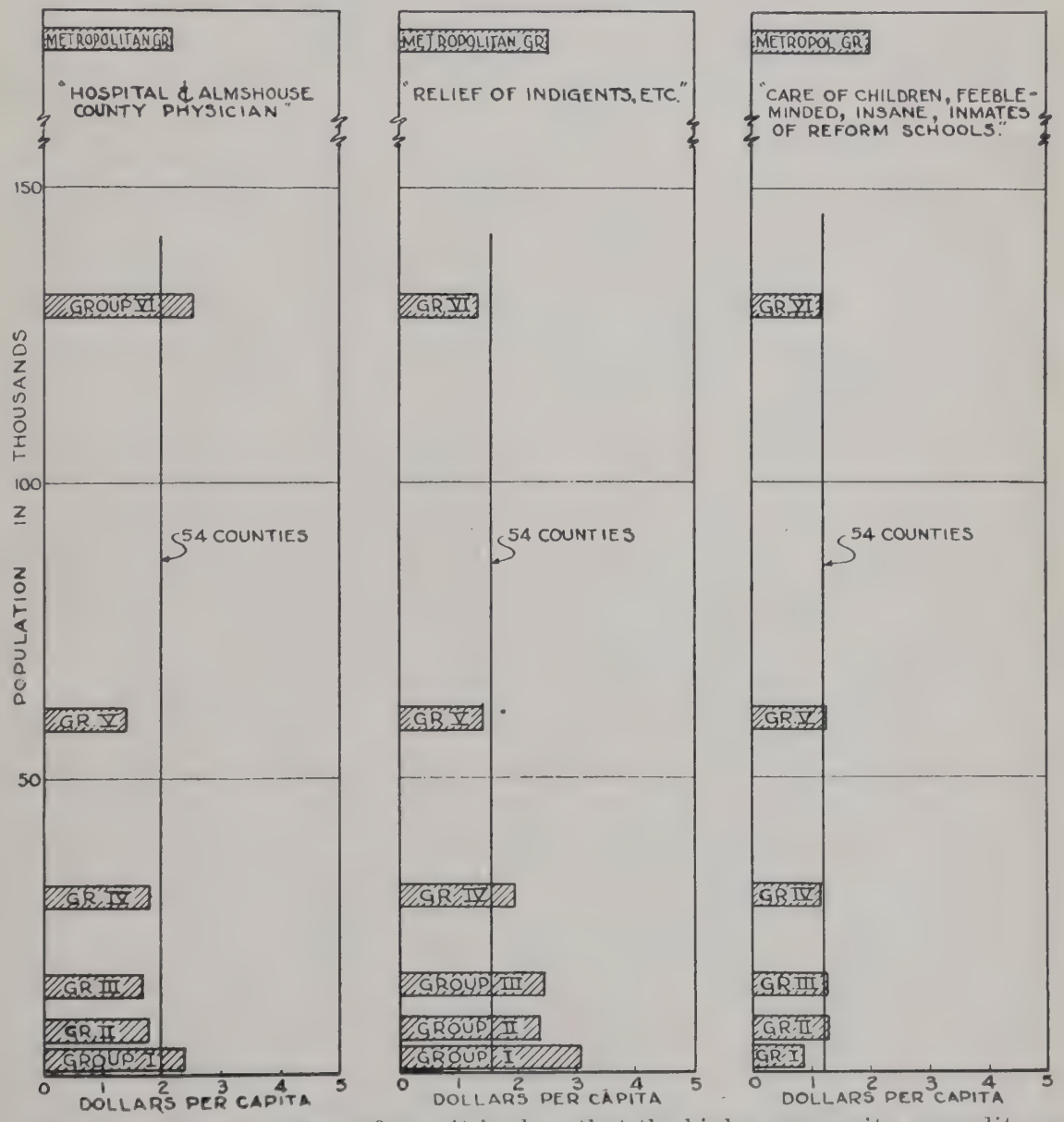


Fig. 15.—From the above figure it is clear that the higher per-capita expenditures for charities and corrections in the smaller counties are the result of higher levels for both institutional services and direct relief in the years considered. (Data from table 14.)

For the 54 counties the only remaining item of considerable proportions beyond the two above considered is that for juvenile relief and delinquency. Care of indigent children, which might properly be included with general indigent relief, although it has markedly different sociological aspects, accounts for about two-thirds of the $1,527,296

devoted to this function by the 54 counties or, roughly, 10 per cent of the total for charities and corrections.

The annual charge upon the counties for support of the mentally defective amounts to approximately $275,000 for the 54 counties or 2.7 per cent of the total for charities and corrections. All counties spend rather more than twice this amount, although the larger total expenditure for charities and corrections lowers the proportion for the mentally defective to 2.3 per cent. In appraising the above figures as such it is to be recalled that the amounts cited represent only the counties' share in the support of these socially burdensome groups.

The significance of the item of "outlays" which, though relatively small for the 54 counties, is of some magnitude in the case of the metropolitan counties, is discussed in Appendix A (page 102). Here as elsewhere it represents a rough separation of expenditure of a permanent character from that of current nature and it logically forms a part of the above-mentioned expenditures were there any basis for allocating it.[35]

It is apparent (fig. 15) that the high levels in large and small counties are not the result of opposing trends for different items which result in a low mean average for the median counties. Both of the major expenditure components of charities and corrections show a strong tendency to reach their high points with the very large and very small counties. Expenditure for the county hospital and almshouse stands at $2.38 per capita for the smallest county group and shows a decline for each of the succeeding larger groups. While this decrease is interrupted slightly in the case of group IV, a low point of $1.37 per capita is reached with group V—counties having populations of from 40,000 to 80,000—and it is sharply higher in the case of the two remaining groups of larger counties.

The comparative levels in the case of relief and the smaller expenditures included therewith are similar to the above for the different county groups. Popular opinion undoubtedly to the contrary, the counties with populations of from 0 to 5,000 expended more for indigent relief in relation to the number of people residing therein than did any other group of counties. From a per-capita level of $3.09 for the group just mentioned, there is an unbroken decline in passing to larger groups until a low point of $1.36 is reached for the counties with populations in excess of 80,000—slightly though not significantly below the $1.43 expended by counties in the population group of from 40,000 to 80,000.

The remaining items comprising expenditure for charities and corrections do not show any such pronounced trends as between small.

[35] In the case of the metropolitan counties there is some possibility that certain bond funds expended for relief are reported in part under this heading.

medium, and large counties as do the larger items just considered. Expenditure for juvenile relief and correction shows some slight variation from one group of counties to another but no pronounced trend. Expenditure for the mentally defective shows a tendency to increase from the small counties to the larger, although the highest expenditure on the basis of population is made by counties in group III with populations from 10,000 to 20,000.

The item of "outlays" shows the most pronounced trend, increasing with but one interruption from the smaller counties to the larger. Aside from the metropolitan counties, however, it is not large enough to affect the general levels of the expenditure as a whole. Taken together (fig. 15) these minor items come to approximately similar levels on a per-capita basis for the various groups of counties except in the case of the smallest county group and the metropolitan counties. Such being the case, it must be concluded that the services, expenditure for which is responsible for the high comparative levels of expenditure for charities and corrections in the larger county groups, are also the ones responsible for the high levels in the smaller counties.

As to the causes of the relatively higher levels of relief and institutional expenditure in the larger counties, the weight of expenditure for direct relief of a large proportion of the population is unquestionably a major factor for the years in question. By recalling the steady increase in expenditure for charities and corrections over the last two decades, it may well be that a more rapid rise in the standards of hospitalization and institutional poor relief in the larger counties is also an important factor. The high expenditure for county hospital and almshouse on the part of counties in group VI (table 14 and fig. 15), would tend to substantiate this belief. It is also to be recalled that the counties in the larger population groups (even exclusive of the metropolitan counties) have very considerable cities therein with the consequent possibility of a larger proportion of the population requiring institutional relief in old age than the more strictly rural counties with their more elastic standards for human obsolescence.

The factors basic to the higher levels of expenditure in the very small counties would appear to be two in number. In contrast with the intermediate county groups, these counties have not as stable or as well-based an economic organization. The economic difficulties of the lumbering industry and many branches of the mining industry during at least two of the three years here considered are well known and would be expected to reflect in the levels of the expenditure for relief—institutional and direct—in a more acute fashion than in the case of the agricultural areas where subsistence from the land tends to act as a buffer between

poverty and public assistance. Moreover, it is fair to say that a considerable number of the smaller counties contain areas where the margin between self-support and public aid is always narrower than in the agricultural counties. This would tend to reflect in a permanently higher level of welfare expenditure.

The other, and perhaps more important, factor, basic to higher levels of expenditure by the smaller counties, is that of the small size of the unit. Maintenance of institutions by a very small county, with consequent greater relative overhead, is likely to be less economical than in counties of moderate size. This factor has been mentioned in the case of highways and receives detailed consideration in the case of general government.

EXPENDITURE FOR GENERAL GOVERNMENT

Expenditure for general government differs somewhat from the other expenditures of county governments. Covered in the main by this disbursement are the assessment and collection of taxes, administration of county finances including in particular the offices of auditor and treasurer, the support of the board of supervisors, the administration of justice, including the county's share in the salaries of Superior Court judges, the holding of elections, and the upkeep of county buildings for housing the functions just indicated. With certain exceptions, of which the most important are the expenditures for the administration of justice, it will be seen that many of these functions are not a part of the direct services which counties exist to perform. Rather as in the case of collection and administration of funds and general supervision of county business, they make possible the performance of county services. To draw an analogy to business organization, many of the expenditures for general government are expenditures for the *overhead* costs of the county, in the same fashion that expenditures for plant upkeep and executive are a part of the overhead costs of business organization.

Overhead costs as such are as essential as are the prime or direct costs of operation. Rent of a factory building is usually quite as essential an expenditure of a manufacturing concern as the expenditures for the raw materials to be fabricated. However, the size of the overhead charges in relation to operating expenditures is a commonplace and often a very good indicator of the efficiency of operation. In approaching the examination of general government expenditures, it is of importance that this overhead character be kept in mind, and also that the volume of general government expenditure—for assessment, collection of taxes, auditing, etc.—in relation to other expenditures be recognized as one of the valuable indicators of the efficiency of county operation.

During the three years under consideration, the 54 counties spent an annual average of $9,063,569 or 7.6 per cent of their total expenditure

TABLE 15

AMOUNT, PER CENT OF ALL EXPENDITURES, AND PER-CAPITA LEVELS OF EXPENDITURE FOR GENERAL GOVERNMENT BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per cent of all expenditures	Per capita	Counties and groups of counties	Amount	Per cent of all expenditures	Per capita
Group I, 0-5,000	$ 181,010	15.7	$12.23	Group IV (*Cont.*)			
Alpine	10,891	20.4	45.19	Butte	$ 162,094	8.1	$4.76
Mono	25,571	24.9	18.80	Merced	164,797	7.1	4.49
Sierra	25,988	16.6	10.73	Santa Cruz	129,099	7.1	3.45
Trinity	33,648	18.4	11.98				
Mariposa	30,679	14.1	9.49	Group V, 40,000-80,000	3,003,627	7.6	4.21
Del Norte	54,233	12.3	11.44	Solano	133,546	8.0	3.27
				Marin	156,048	7.3	3.75
Group II, 5,000-10,000	446,684	12.1	7.23	Humboldt	212,551	8.9	4.92
Calaveras	45,060	12.0	7.50	Monterey	208,517	5.9	3.88
Inyo	52,788	11.9	8.05	Ventura	447,884	11.3	8.15
Lake	81,753	15.4	11.41	Stanislaus	170,202	5.9	3.00
Plumas	53,464	9.8	6.76	Imperial	250,202	9.6	4.11
Modoc	63,061	12.7	7.84	Sonoma	220,588	7.4	3.55
El Dorado	51,733	11.4	6.21	Santa Barbara	297,313	6.3	4.56
Amador	34,401	10.4	4.05	San Mateo	266,898	7.1	3.45
Tuolumne	64,424	12.1	6.95	Tulare	269,331	6.8	3.48
				Contra Costa	370,547	7.8	4.72
Group III, 10,000-20,000	754,205	9.3	5.96	Group VI, 80,000 and over	3,474,572	6.8	3.66
Colusa	62,353	7.1	6.08	Riverside	403,485	9.4	4.98
Nevada	53,198	12.4	5.02	Kern	432,047	6.5	5.23
Glenn	85,496	9.9	7.82	San Joaquin	370,812	7.1	3.60
San Benito	56,535	9.3	5.00	Orange	425,056	5.2	3.58
Yuba	71,517	8.8	6.31	San Bernardino	466,846	7.4	3.48
Lassen	80,781	10.9	6.42	Sacramento	457,632	7.5	3.22
Tehama	78,821	9.5	5.68	Fresno	476,020	6.4	3.29
Shasta	95,536	11.3	6.86	Santa Clara	442,674	6.3	3.05
Sutter	81,873	7.4	5.60				
Madera	88,095	8.7	5.14	Total, 54 counties	9,063,569	7.6	4.22
Group IV, 20,000-40,000	1,203,471	7.6	4.25	Metropolitan group	9,987,927	6.7	3.45
Napa	104,983	9.9	4.59	San Diego	897,641	8.6	4.28
Mendocino	109,547	8.3	4.66	Alameda	1,222,348	6.1	2.57
Yolo	103,578	7.2	4.38	Los Angeles	7,867,938	6.6	3.56
Placer	85,788	7.9	3.51				
Kings	95,839	6.8	3.78				
Siskiyou	100,784	8.3	3.95	Total, all counties*	$19,051,496	7.1	$3.78
San Luis Obispo	$ 146,962	6.9	$ 4.96				

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

for general government. Including the metropolitan counties, the expenditure for this item was $19,051,496 or 7.1 per cent of the combined expenditure of all counties. If the reader's exposure to figures already

considered has not led him to the adoption of somewhat inflated standards for appraisal of volume of expenditure, it will be realized that the annual disbursement for general government in California is a sizable one, even though it does not occupy a large place in the budget as a whole.

Examination of table 15 and fig. 16 will show that the figures on proportion of expenditure for general government for all counties are far from providing a true picture of the situation in individual counties, particularly in the smaller counties. While all counties, it is true, spend but 7.1 per cent of their total budget for this item, with some of the larger counties substantially below this figure, the group of smallest counties devotes nearly 16 per cent of its total to this function. Individual counties in the latter group even exceed this proportion by a substantial amount as, for example, Mono County with approximately 25 per cent of all expenditures for general government, and Alpine and Trinity with approximately 20 per cent for this function.

In passing to the larger county groups, a marked and regular decline is noted in the proportion of expenditure devoted to general government with increased county size. Group II, with populations of from 5,000 to 10,000, devotes 3.6 per cent less than group I. Group III, in turn, devotes 2.8 per cent less than group II, and group IV, 1.7 per cent less than group III. While there is no appreciable change between groups IV and V, there is a further decline of 0.8 per cent to the 6.8 per cent devoted to general government by group VI which includes the most populous of the 54 counties. While the decline in proportion of the total devoted to this function is a regular one (fig. 16), there is, however, a marked tendency for it to level out after the 20,000 mark is reached in population. From group I through group III there is a drop in the proportion devoted to general government of 8.1 per cent or by an amount greater than the level for the 54 counties as a whole. From group IV, with populations of from 20,000 to 40,000, to group VI there is a drop of but 0.8 per cent, with a decline of an additional 0.1 per cent in the case of the metropolitan counties.

While it is clear from the above that there are markedly greater demands on the county budget for general government below a certain minimum population, this situation is seen in particularly clear relief when the expenditures for the general government for different counties are compared on the basis of population. From a per capita of $12.23 expended by counties in group I with populations of less than 5,000 there is a drop to $7.23 for group II and to $5.96 for group III. The leveling out begins, however, with group IV, which shows a per-capita disbursement of $4.25, and from which there is a drop of but $0.04 to

group V with counties having populations of from 40,000 to 80,000. A further decline to $3.66 occurs for group VI, counties having populations in excess of 80,000, although considering the extent of the popula-

Comparative Per-Capita Expenditure and Proportion of All Expenditure for General Government by Groups of California Counties, Average Annual 1929–30 to 1931–32

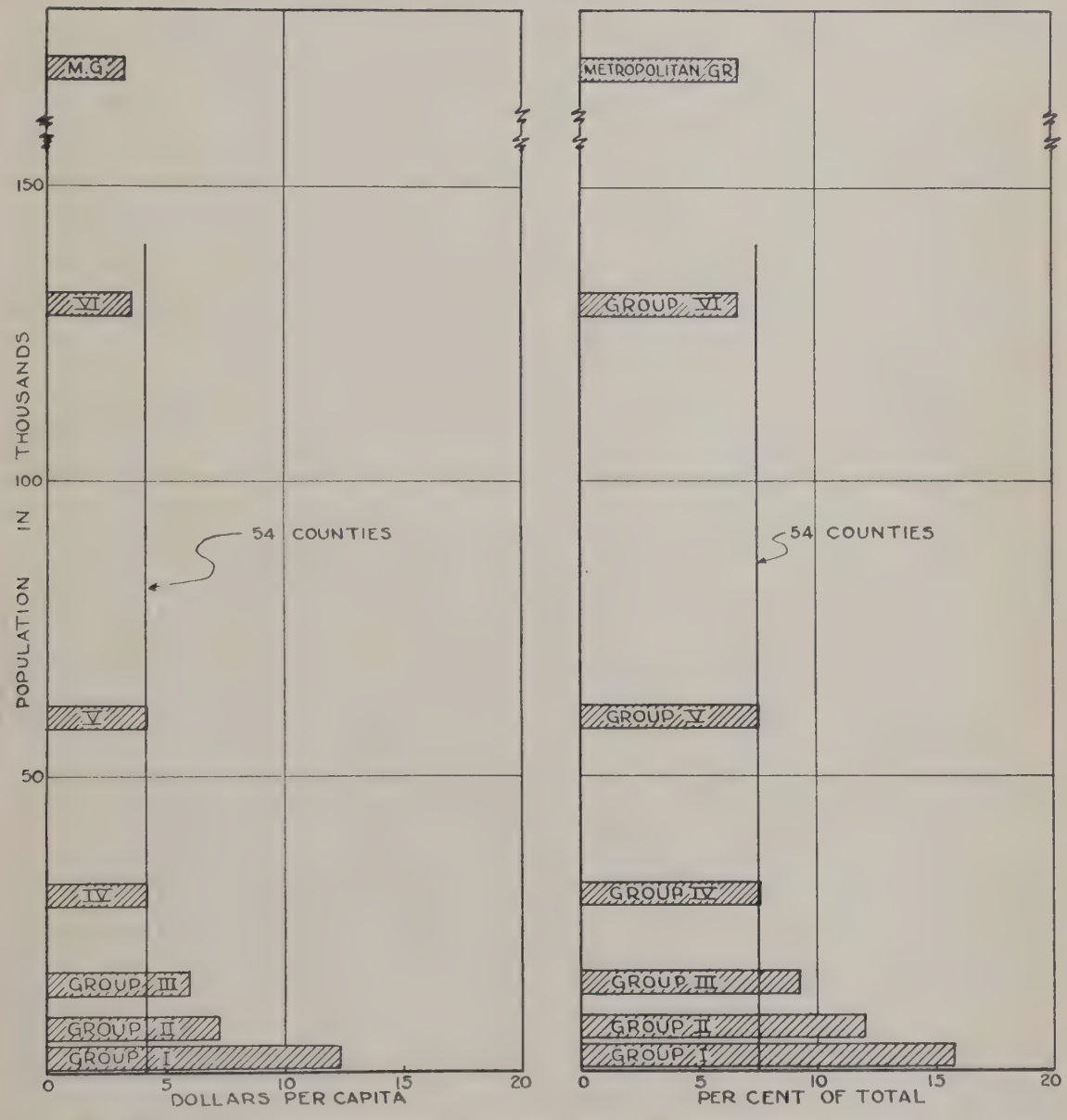


Fig. 16.—The per-capita expenditure for general government by the larger counties and the proportion of the total devoted to this function are markedly lower than in the case of the smaller counties, especially those comprising groups I, II, and III. (Data from table 15.)

tion change involved, this is much smaller than the change between the smaller groups. Counties in group VI, it will be noticed, spend on a per-capita basis but slightly more than one-fourth as much for general government as do counties in group I, and approximately half of the amount expended by counties in group II.

It is apparent that the comparative expenditure for general government decreases with increase in the number of people served, as might be expected of an overhead cost. The statutory officers of the county and the core of county legislative and administrative organization are maintained by small county and large county alike. While there is, of course, an increase in staff and salaries,[36] with an increase in the size of the

THE RELATION BETWEEN SIZE OF COUNTY AND EXPENDITURE FOR GENERAL GOVERNMENT, 54 COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

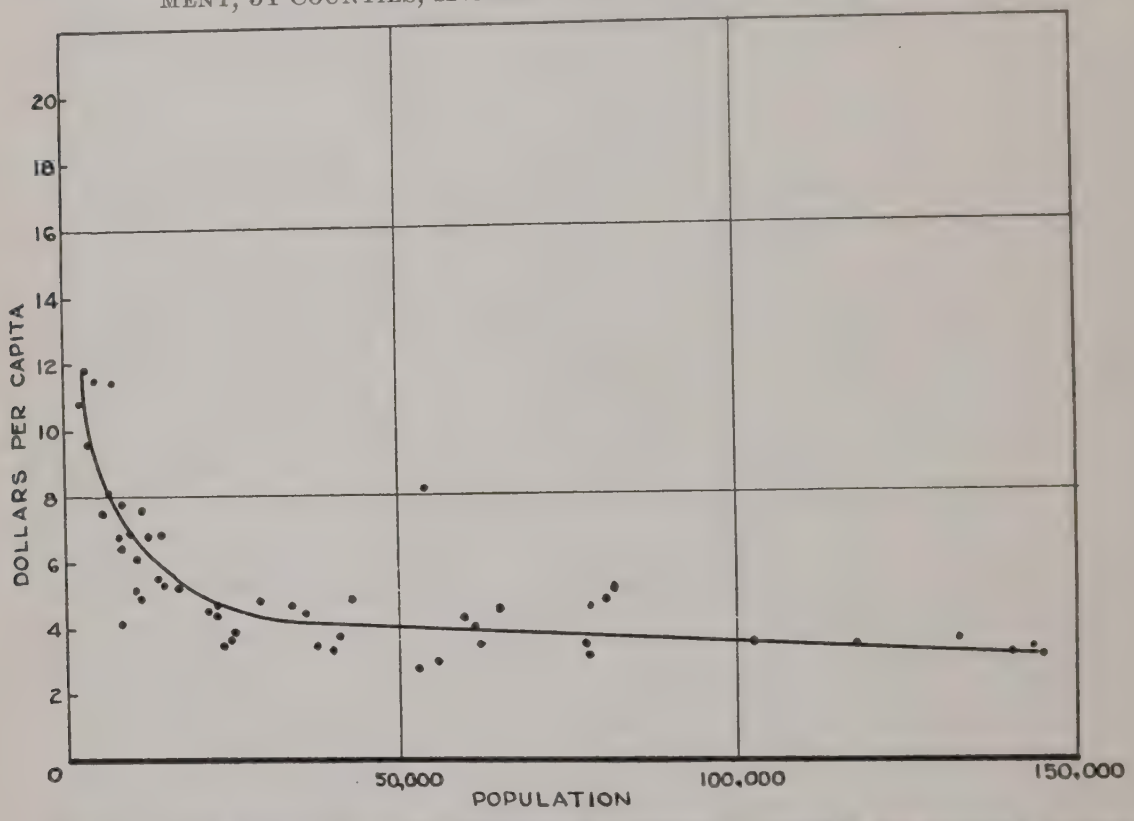


Fig. 17.—The per-capita expenditures of individual counties for general government group themselves closely about a mean line describing the relation between size of county and per-capita expenditure. The few cases of extreme dispersion in the above figure are the result of capital disbursements. (Data from table 15, curve fitted by group averages.)

county, it is apparent that this increase is at a much less rapid rate than the increase in the number of people served.

It may of course be suggested that other characteristics of the counties in the smaller population groups—sparseness of settlement and possibly other factors—may be responsible for the higher per-capita levels of expenditure for general government in these smaller counties. When the relation between population and expenditure is examined for individual counties (fig. 17), this argument loses any of the conviction

[36] For a more complete treatment of this item see: California Commission on County Home Rule. Final report. p. 112–136. California State Printing Office, Sacramento. 1931.

it might otherwise carry. The expenditures for individual counties cluster with surprising closeness about a mean line describing the relation between population and per-capita expenditure.[37] Moreover, counties with a relatively sparse population, such as Siskiyou and Tehama, but with a considerable area and hence a considerable total population, are uniformly in their expected position along the curve in figure 17 and with no higher per-capita expenditures for general government than valley counties of similar total population but with much smaller area and much greater density of population.

In some respects the expenditure for general government is more homogeneous in purpose than certain of the other expenditure groups, such as charities and corrections or protection to persons and property. An adequate view of this item, however, involves consideration of the relative importance of the constituent parts of the expenditure and their comparative levels as between county groups. From this also comes identification of the individual items responsible for the higher levels of expenditure in the smaller county groups.

Most costly as a group among the functions included under general government are those concerned with the gathering and administering of county finances and referred to in table 16 as *finance offices*. During the three-year period, support of the auditor, treasurer, assessor, and tax collector, with office staffs and incidental expenses, amounted to $2,436,-969 for the 54 counties, or approximately 27 per cent of their total expenditure for general government (table 16).

While examination of figure 18 will show that the higher levels of expenditure for finance offices and administration in the smaller counties contributed in no small degree to the higher expenditure for general government in these counties, the decline with increasing county size is not marked beyond a population of, roughly, 20,000. It would appear that the counties smaller than this in population do pay a substantial amount for maintenance of the fiscal machinery regardless of the "volume of business" as evidenced by the decline of 62 per cent in comparative, or per-capita, levels for this item from group I to group IV and of 37 per cent from group II to group IV. Mountain counties, which as a result of large areas have populations sufficient to place them in group IV, although they have a density of population and general character similar to that of the smaller counties, do not show expenditures out of line with the more densely populated counties of the groups in which they fall.

[37] This relation shows even less dispersion when the item of "outlays" (Appendix A, page 102) is removed. Expenditures for capital improvements and construction under way during the period of the study "show through" the three-year average for certain counties, most notably in the case of Ventura.

The further fact that assessment, tax collection, and financial administration generally level out after a certain county size is reached is not difficult to understand. Once the statutory machinery is fully utilized, increases in the tax base and volume of transactions doubtless involve increases in the expenditure for assessment, tax collection, and administration, but slightly less in proportion.

TABLE 16

DETAIL OF EXPENDITURE FOR GENERAL GOVERNMENT BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Classifications Concluded on Opposite Page

County group	Finance offices			Legislative offices			Elections		
	Amount	Per cent of total for general government	Per capita	Amount	Per cent of total for general government	Per capita	Amount	Per cent of total for general government	Per capita
Group I	$ 46,469	25.7	$3.14	$ 46,265	25.6	$3.13	$ 10,997	6.1	$0.74
Group II	117,126	26.2	1.90	96,639	21.6	1.56	28,622	6.4	0.46
Group III	202,350	26.8	1.60	177,624	23.6	1.40	54,965	7.3	0.43
Group IV	337,258	28.0	1.19	218,517	18.1	0.77	94,874	7.9	0.34
Group V	745,921	24.8	1.05	445,651	14.8	0.63	203,933	6.8	0.29
Group VI	987,845	28.4	1.04	460,259	13.3	0.48	262,672	7.6	0.28
54 counties	2,436,969	26.9	1.13	1,444,955	16.0	0.67	656,063	7.2	0.31
Metropolitan counties	2,954,027	29.6	1.02	532,181	5.3	0.18	781,866	7.8	0.27
All counties†	$5,390,996	28.3	$1.07	$1,977,136	10.4	$0.39	$1,437,929	7.5	$0.29

† Excluding City and County of San Francisco.

In contrast with the expenditure for maintenance of the financial administration, expenditure for the board of supervisors and county clerk, indicated in table 16, as *legislative offices*,[38] shows a steady decline from the group of smaller counties through the groups of larger counties. For counties in group I, support of the county board involves an expenditure nearly equal to that for the finance offices and accounts and 25.6 per cent of the total expenditure for general government. Counties in group II devote but 21.6 per cent of the total for general government to support of the board and clerk, and on a per-capita basis

[38] For purposes of possible future identification it has been deemed wise to preserve, in so far as possible, the terminology of the State Controller's Office in labeling statistical material in this and other sections. The term "legislative" in connection with the board of supervisors is not, in the eyes of many authorities, a particularly apt one. (See: Farlie, John A., and Charles M. Kneir. County government and administration. p. 108. Century Co., New York. 1930.) In keeping with the above policy, however, it has been retained herein.

expend $1.56 or almost exactly half of that expended by counties in group I. Succeeding county groups show a steadily decreasing per-capita expenditure, and likewise a steadily decreasing proportion of the general government expenditure devoted to support of the county board and clerk. In the case of the larger county groups this expenditure, on a per-capita basis, is but a fraction of that of the smaller counties. Thus,

TABLE 16—*(Concluded)*

Detail of Expenditure for General Government by Groups of California Counties, Average Annual 1929–30 to 1931–32

Other executive offices*			Law offices			Judicial offices			General government buildings and "outlays"		
Amount	Per cent of total for general government	Per capita	Amount	Per cent of total for general government	Per capita	Amount	Per cent of total for general government	Per capita	Amount	Per cent of total for general government	Per capita
$ 4,796	2.6	$0.32	$ 24,866	13 7	$1.68	$ 28,435	15.7	$1.92	$ 19,183	10.6	$1.30
15,958	3.6	0.26	37,063	8.3	0.60	69,385	15.5	1.12	81,892	18.4	1.33
47,553	6.3	0.38	62,678	8.3	0.50	122,993	16 3	0.97	86,041	11.4	0.68
105,556	8.8	0.37	110,784	9.2	0.39	221,103	18.4	0.78	115,383	9.6	0.41
309,956	10.3	0.43	296,394	9.9	0.41	466,771	15.6	0.65	534,999	17.8	0.75
276,104	7.9	0.29	308,847	8.9	0.33	604,491	17.4	0.64	574,351	16.5	0.60
759,923	8.4	0.35	840,632	9.3	0.39	1,513,178	16.7	0.70	1,411,849	15.6	0.66
1,501,163	15.0	0.52	1,027,854	10.3	0.36	1,917,842	19.2	0.66	1,272,994	12.8	0.44
$2,261,086	11.9	$0.45	$1,868,486	9.8	$0.37	$3,431,020	18.0	$0.68	$2,684,843	14.1	$0.53

* Coroner, surveyor, and purchasing agent.

Source of data: Computations by author based on "Financial transactions."

in the case of counties in group IV, it is less than one-sixth, and in the case of the metropolitan counties less than one-seventeenth of that for group I.

Among the various components of general government, expenditure for legislative offices shows the most pronounced decreasing-cost tendency with increasing county size (fig. 18). That it should decrease through the whole range of counties in contrast with other items, rather than in a pronounced manner for the smaller counties alone, is not strange in view of the function involved. While, as earlier indicated, higher salaries, including those of the supervisors,[39] are general in the larger counties and the staff of the county clerk is somewhat expanded, these increases do not keep pace with increasing size in the same way as

[39] California Commission on County Home Rule. Final report. p. 112–136. California State Printing Office, Sacramento. 1931.

demands on the offices of assessor and tax collector or other finance offices. The result is a regular and sustained decline in the per-capita expenditure for the board of supervisors as the unit administered becomes larger.

COMPARATIVE PER-CAPITA EXPENDITURE FOR VARIOUS FUNCTIONS INCLUDED UNDER GENERAL GOVERNMENT BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

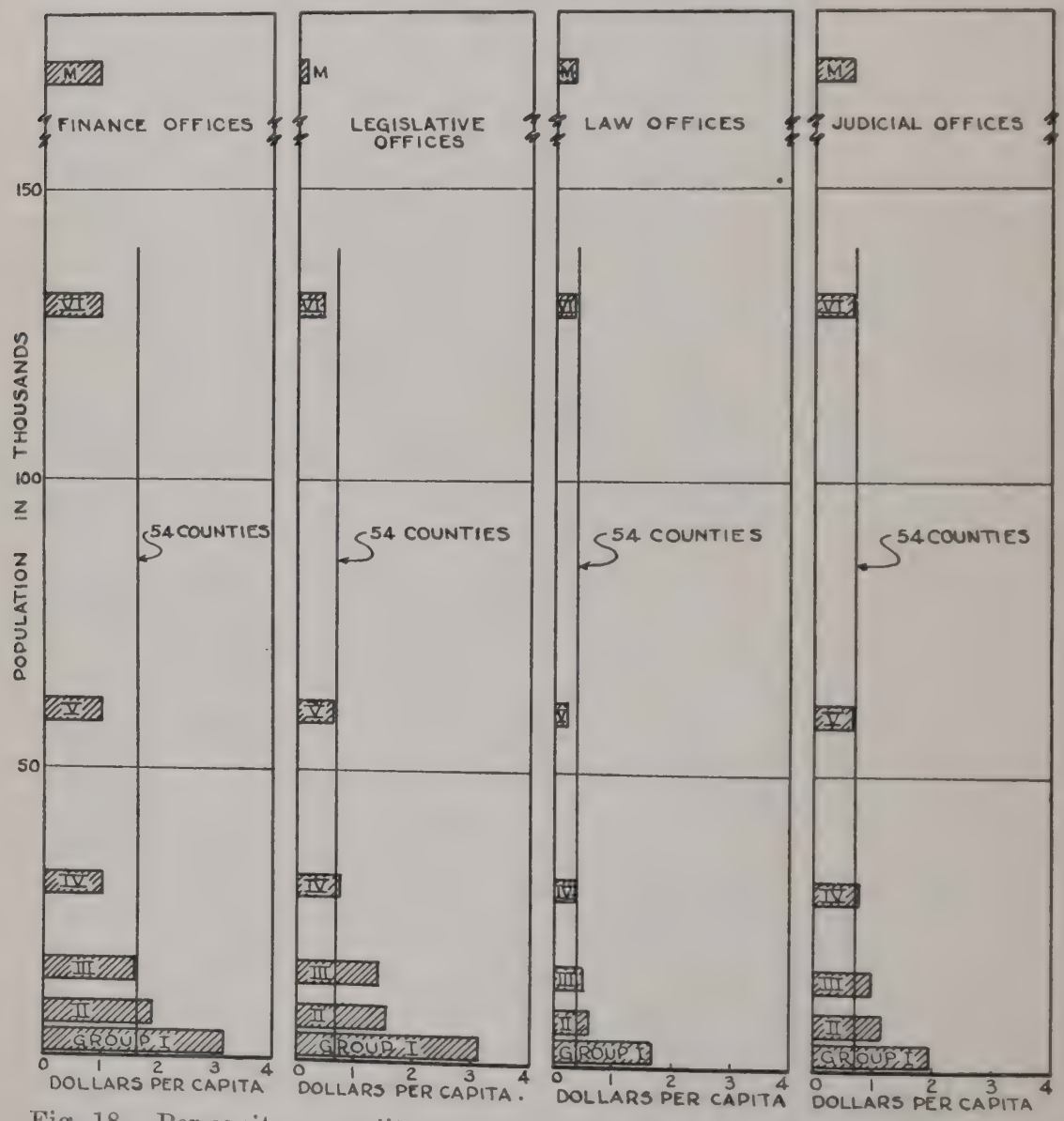


Fig. 18.—Per-capita expenditures for all of the functions coming under general government show a decrease in passing from the smaller to the larger counties. (Data from table 16.)

Elections, over the period considered, accounted for an annual average of 7.2 per cent of the general government expenditure for the 54 counties, and a slightly higher proportion for all counties combined. Save for the metropolitan counties, a general decrease in the comparative, or per-capita, levels for this item is to be noted in passing from the small

counties to the larger ones. While this is not a large item of expenditure it is significant that there is a drop of approximately 38 per cent in the per-capita cost for elections, exclusive of the services performed by the county clerk in preparing registration lists, in passing from group I to group II, and subsequent declines bring the level for group IV to less than half of that for group I. For this item again there is little evidence of factors other than that of size, in terms of total population, influencing the level of expenditure. Counties with sparse population but of considerable area do not show expenditure for this item at variance with smaller and more densely populated counties of similar total population.[40] On the other hand, the high cost of setting up the machinery for this function with a small population is illustrated by the per-capita expenditure of $0.80 by Sierra, $0.82 by Mono, and $1.68 by Alpine, respectively—the third smallest, second smallest, and smallest county of the state.

With the exception of "general government buildings and 'outlays' " the remaining items of expenditure under general government are of a slightly different order from those hitherto considered. Remaining items combine a greater degree of service with the purely administrative function or, as in the case of the expenditure for "judicial offices," are almost entirely for the performance of services.

Expenditure for other *executive offices,* which covers chiefly the support of the coroner, surveyor, and purchasing agent, involves 8.4 per cent of the general government total for the 54 counties. There is little in the way of a definite trend in the comparative levels of this expenditure among the 54 counties, although some increase is to be noted in the proportion of all general government expenditures devoted to these offices by the groups of larger counties. For the metropolitan counties in particular there are sharp increases in the per-capita expenditure and in the proportion of the total general government budget. The activities of the coroner's office apparently increase, as might be expected, roughly in proportion to the population. Centralized purchasing, however, appears to be of chief importance in raising the expenditure levels for this group of offices in the large counties. It is perhaps unnecessary to point out that an increased comparative expenditure under this last item may well indicate much more than commensurate economy in the expenditures of the county as a whole.

The expenditure for district attorney, listed in table 16 as for *law*

[40] Thus the per-capita expenditure for Shasta County was $0.39 and for Tehama $0.41 which compares favorably with $0.45 for Sutter and $0.45 for Yuba. The latter pair of counties, with approximately the same total population as the first mentioned, have but a fraction of the physical area and a population that is several times more concentrated.

offices, is perhaps the best illustration of the high cost of statutory maintenance of offices in the very small counties. For the 54 counties this office involved an average expenditure of $840,632 for the period covered, amounting to 9.3 per cent of the general government total and $0.39 per capita. In contrast with this, the counties in group I expended 13.7 per cent of their general government total for the support of the district attorney or $1.68 per capita. This was more than four times the 54-county per capita, and nearly three times as much as the per-capita expenditure of counties in group II with populations between 5,000 and 10,000. A further decline of 16 per cent is to be noted from counties in group II to those in group III, and of 33 per cent between group II and group IV. In this item, the sparsely populated mountainous counties that have, however, a large area and, hence, considerable population again show no significant deviation in comparative expenditure from the smaller area and more densely populated valley counties with which they are grouped. Here, likewise, the comparative levels of expenditure again soar to almost fantastic levels in the very small counties with a per capita of $1.90 for Mono, $2.43 for Del Norte, and $4.90 for Alpine.

For the 54 counties the second largest expenditure coming under general government is that listed in table 16 for *judicial offices*, amounting to an annual average for the period considered of $1,513,178 or 16.7 per cent of the total for general government. This expenditure covers the county's share in the salary of the Superior Court judge, support of the Superior and Justice courts, including witness and trial jury fees, support of the grand jury, and maintenance of the law library. It has been left to this point in the discussion of general government because it embraces a major degree of service in contrast with the greater or lesser degree of administrative character of the subjects of expenditure previously discussed. It covers, in short, functions which the county exists to perform rather than those which it performs to exist.

Although expenditure for administration of justice occupies a slightly larger proportion of the total general government expenditure in the larger counties, the typically rapid decline in per-capita levels in passing from smaller to larger counties is again apparent. Likewise there is a leveling out as the very large units are reached. In comparison with the 54-county per capita of $0.70, counties in group I devote $1.92 to this function and counties in group II, $1.12. For counties in group III there is a further drop in per-capita expenditure to $0.97 and subsequent, although less abrupt, declines bring the level for groups V and VI to about one-third of that for group I.

Expenditure for administration of justice is not solely for a service to persons, and hence the per-capita basis of comparison does not have

quite the same justification as in the case of other general government items devoted to the provision for administration and services which are, in total for the county, perhaps 80 per cent for persons (page 34). On the other hand, it is difficult to see how the differences in wealth or property, as between large and small counties, could account for the differences in per-capita levels as shown. And once again the soaring figures for the counties of very small population are indicative of a close relation with the size of the unit involved, as measured by population.

The final item, listed as *general government buildings and "outlays"* may be disposed of rather briefly. Amounting to $1,411,849 or 15.6 per cent of the total general government expenditure for the 54 counties, this expenditure is by no means a negligible part of the total. Inasmuch however, as it includes an inseparable element of capital expenditure for certain counties which may well show through the three-year average, only the broadest of generalizations may be made. There is some indication that the smaller counties have a higher comparative level of expenditure for the maintenance of the courthouse than do the larger counties, although there is no consistent trend in the proportion of the budget devoted to this item in passing from smaller counties to the larger ones. Data for the individual counties show considerable irregularity, and consequently the figures for the county groups as a whole are somewhat lacking in signifiance.

In concluding the consideration of the various items comprising general government, it is fitting to say that among all of the expenditures of the county this is probably the most thought-provoking, in light of the expenditure situation, which exists. Both for the item as a whole and for its component parts, evidence is abundant that the geographically imaginary lines which demark certain of the counties of the state, however real they may be to local pride and vested interest, are contributing to a highly uneconomical surplus of administrative (and service) machinery. Part of this surplus, we have seen, undoubtedly owes existence to laws formulated for all counties alike. A larger though less tangible part is probably inevitable, in the nature of the case, as long as counties and county boundaries remain as they are.

EXPENDITURE FOR PROTECTION TO PERSONS AND PROPERTY

For the period 1929–30 to 1931–32, the average annual expenditure for the services of the county coming under the heading of protection to persons and property amounted to $5,533,551 or 4.6 per cent of the total expenditures of the 54 counties (table 17). For all counties of the state, expenditure for this item totaled $13,153,990 or 4.9 per cent of

TABLE 17

AMOUNT, PER CENT OF ALL EXPENDITURES, AND PER-CAPITA LEVELS OF EXPENDITURE FOR PROTECTION TO PERSONS AND PROPERTY BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per cent of all expenditures	Per capita	Counties and groups of counties	Amount	Per cent of all expenditures	Per capita
Group I, 0-5,000	$ 64,825	5.6	$4.38	Group IV (*Cont.*)			
Alpine	2,334	4.4	9.68	Butte	$ 83,382	4.2	$2.44
Mono	7,648	7.5	5.62	Merced	154,203	6.7	4.20
Sierra	5,469	3.5	2.26	Santa Cruz	96,372	5.3	2.57
Trinity	11,058	6.1	3.94				
Mariposa	11,237	5.2	3.48	Group V, 40,000-80,000	1,920,631	4.9	2.70
Del Norte	27,079	6.1	5.71	Solano	81,949	4.9	2.01
				Marin	69,662	3.3	1.67
Group II, 5,000-10,000	199,897	5.4	3.24	Humboldt	143,604	6.0	3.32
Calaveras	20,911	5.6	3.48	Monterey	142,800	4.1	2.66
Inyo	26,211	5.9	4.00	Ventura	240,788	6.1	4.38
Lake	29,908	5.7	4.18	Stanislaus	155,522	5.4	2.74
Plumas	21,603	4.0	2.73	Imperial	157,780	6.1	2.59
Modoc	30,747	6.2	3.83	Sonoma	108,944	3.6	1.75
El Dorado	22,112	4.9	2.66	Santa Barbara	242,040	5.2	3.71
Amador	14,418	4.4	1.70	San Mateo	121,999	3.3	1.57
Tuolumne	33,987	6.4	3.67	Tulare	228,107	5.7	2.94
				Contra Costa	227,436	4.8	2.89
Group III, 10,000-20,000	199,897	5.4	3.24	Group VI, 80,000 and over	2,106,140	4.1	2.22
Colusa	42,677	4.8	4.16	Riverside	275,702	6.4	3.40
Nevada	25,274	5.9	2.38	Kern	237,977	3.6	2.88
Glenn	60,432	7.0	5.53	San Joaquin	264,609	5.1	2.57
San Benito	31,933	5.2	2.82	Orange	374,103	4.6	3.15
Yuba	46,259	5.7	4.88	San Bernardino	351,530	5.6	2.62
Lassen	43,275	5.8	3.44	Sacramento	189,751	3.1	1.34
Tehama	53,544	6.5	3.86	Fresno	248,611	3.3	1.72
Shasta	53,996	6.4	3.88	Santa Clara	163,857	2.3	1.13
Sutter	51,180	4.6	3.50				
Madera	58,714	5.8	3.42	Total, 54 counties	5,533,551	4.6	2.57
Group IV, 20,000-40,000	774,774	4.9	2.74	Metropolitan group	7,620,439	5.1	2.63
Napa	52,704	5.0	2.30	San Diego	428,085	4.1	2.04
Mendocino	63,052	4.8	2.68	Alameda	498,856	2.5	1.05
Yolo	61,253	4.3	2.59	Los Angeles	6,693,498	5.6	2.04
Placer	42,806	3.9	1.75				
Kings	60,688	4.3	2.39				
Siskiyou	63,990	5.3	2.51	Total, all counties*	$13,153,990	4.9	$2.61
San Luis Obispo	$ 96,324	4.6	$3.25				

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

all expenditure—a slightly higher proportion than when the metropolitan counties are excluded. Examination of the place this expenditure has in the total disbursements of the various county groups fails to show, at first glance, such striking contrasts as have been apparent for earlier items. Group I expends 5.6 per cent of its total for this item, with a

drop to 5.4 per cent for groups II and III, and a further drop to 4.9 per cent for groups IV and V. Group VI reaches the minimum with 4.1 per cent of the total for this group of services. When compared with general

Comparative Per-Capita Expenditure and Proportion of All Expenditure for Protection to Persons and Property by Groups of California Counties, Average Annual 1929–30 to 1931–32

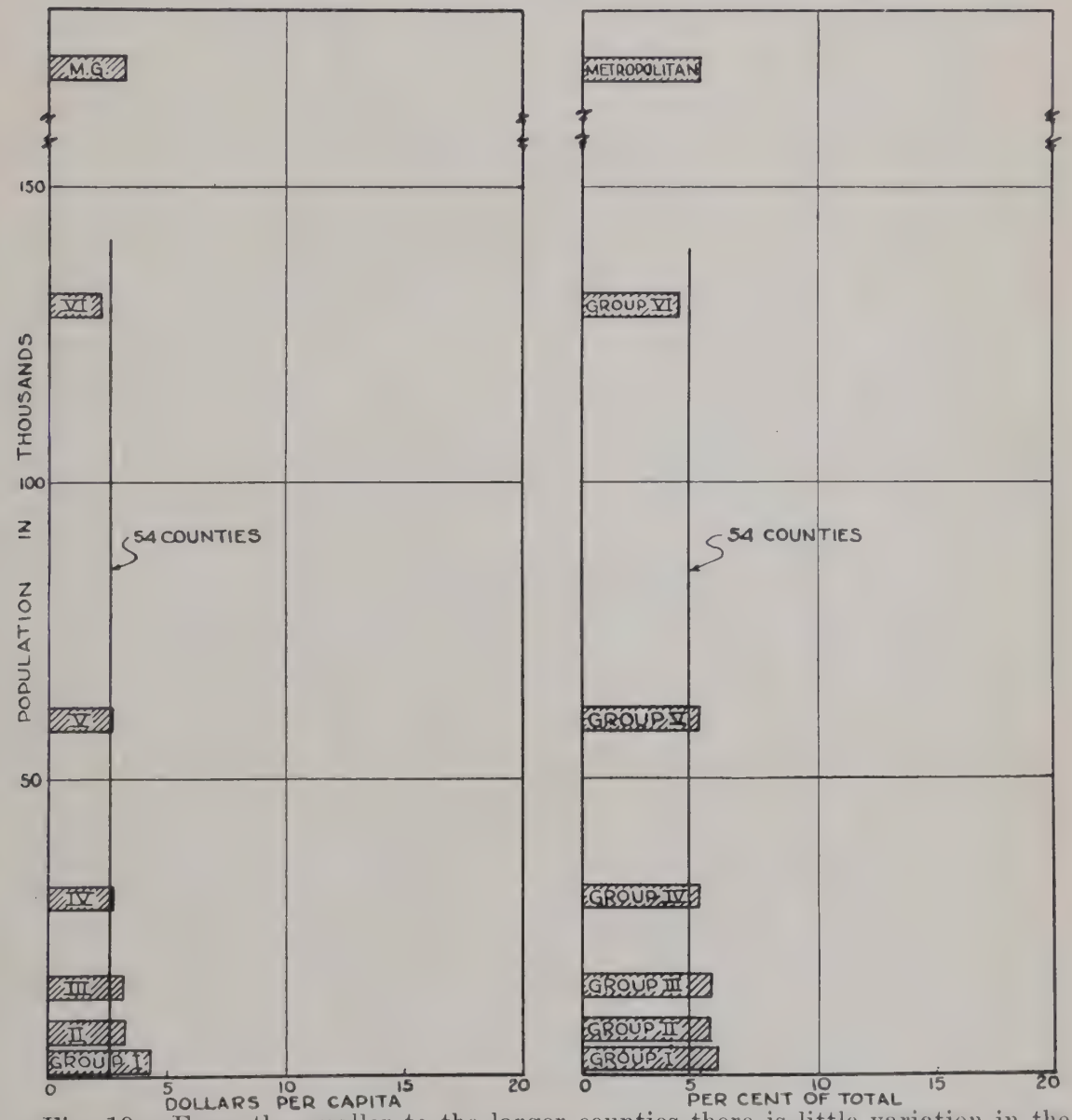


Fig. 19.—From the smaller to the larger counties there is little variation in the proportion of expenditure devoted to protection to persons and property, although there is some decrease in per-capita expenditures. As shown by figure 20, however, there is a marked variation in the composition of the expenditure. (Data from table 17.)

government, the proportion of all expenditures devoted to protection to persons and property by the various groups of counties are seen to be relatively uniform. This uniformity is well illustrated in figure 19.

Turning to comparative, or per-capita, levels of expenditure and again recalling the higher levels of comparative total expenditure for

the small county, a more substantial downward trend is to be noted from the small counties to the larger. Counties in group I expend a per capita of $4.38 for this item and the decline to groups II and III of $1.14 is substantial. A further decline of approximately $0.50 to a per capita of $2.74 and $2.70 occurs for counties in groups IV and V, and group VI shows a further decline to $2.22. Comparative, or per-capita, expenditure for this group of counties is thus about half of that for group I

TABLE 18

DETAIL OF EXPENDITURE FOR PROTECTION TO PERSONS AND PROPERTY BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Classifications Concluded on Opposite P

County group	Sheriff			Constables			County jails			County recorder		
	Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	P cap
Group I	$ 24,883	38.4	$1.68	$ 3,045	4.7	$0.21	$ 4,431	6.8	$0.30	$ 8,561	13.2	$0
Group II	58,336	29.2	0.94	15,293	7.7	0.25	24,460	12.2	0.40	25,643	12.8	0.
Group III	116,951	25.0	0.92	33,134	7.1	0.26	31,578	6.8	0.25	41,161	8.8	0.
Group IV	150,220	19.4	0.53	74,682	9.6	0.26	72,156	9.3	0.26	85,292	11.0	0.
Group V	380,231	19.8	0.53	151,753	7.9	0.21	157,161	8 2	0.22	202,340	10.5	0
Group VI	477,028	22.6	0.50	164,739	7.8	0.17	226,937	10.8	0.24	260,850	12.4	0
54 counties	1,207,649	21.8	0.56	442,646	8.0	0.21	516,723	9.3	0.24	623,847	11.3	0.
Metropolitan group	1,675,024	22.0	0.58	340,667	4.5	0.12	886,175	11.6	0.31	741,782	9.7	0.
All counties*	$2,882,673	21.9	$0 57	$783,313	6 0	$0 16	$1,402,898	10 7	$0 28	$1,365,629	10 4	$0

* Excluding City and County of San Francisco.

and about two-thirds of that for group II. For the metropolitan counties there is an increase of $0.39 in the per-capita expenditure for protection to persons and property.

The interesting features of the expenditure for protection to persons and property as between different counties, however, rest not in the total expenditure figures for this item, but in the distribution to the individual services coming under this heading. The composite character of expenditure for protection to persons and property has been noted on page 21 and, likewise, the possibility of recognizing two logically distinct classes of services thereunder—the criminal (and civil) services of the sheriff, constables, and jail, and the multitude of rather miscel-

laneous services which have been added to the agenda of county activities from time to time and which have been briefly described herein as services for economic welfare.

Table 19 and figure 20 show in striking fashion the difference in the division of expenditure between the above groups of services in the small and large counties. Counties in groups I and II devote approximately half of their total expenditures for protection to persons and

TABLE 18—*(Concluded)*

Detail of Expenditure for Protection to Persons and Property by Groups of California Counties, Average Annual 1929–30 to 1931–32

Agricultural commissioner and farm advisor			Inspection services, game and fire protection, bounties, etc.			Compensation insurance			Outlays		
Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	Per capita
$ 3,937	6.1	$0.27	$ 11,925	18.4	$0.80	$ 5,704	8.8	$0.38	$ 2,339	3.6	$0.16
27,442	13.7	0.44	31,502	15.7	0.51	13,726	6.9	0 22	3,495	1.8	0.06
99,793	21.4	0.79	100,852	21.5	0.80	21,982	4.7	0.17	21,833	4.7	0.17
195,781	25.3	0.69	150,426	19.4	0.53	34,826	4.5	0.12	11,391	1.5	0.04
497,527	25.9	0.70	335,984	17.5	0.47	82,068	4.3	0.12	113,567	5.9	0.16
435,548	20.7	0.46	426,122	20.2	0.45	65,459	3.1	0.07	49,457	2.4	0.05
1,260,028	22.8	0.59	1,056,811	19.1	0.49	223,765	4.0	0.10	202,082	3.7	0.09
370,643	4.9	0.13	1,700,671	22.3	0.58	124,878	1.7	0.04	1,780,599	23.3	0.62
$1,630,671	12.4	$0.32	$2,757,482	21.0	$0.55	$348,643	2.6	$0.07	$1,982,681	15.0	$0.39

Source of data: Computations by author based on "Financial transactions."

property to support of the *sheriff, constables, and jail,* while the varied services of economic welfare accounted for less than 38 per cent of the total.[41] Increasing population, however, brings a pronounced shift in the importance of these two groups until with group IV nearly 56 per cent of the total is for economic welfare, while the sheriff, constables, and jails account for but 38 per cent. For the larger counties there is again some increase in the proportion of expenditure for the latter items.

Examination of table 18 for the basis of the high proportion of protection to persons and property expenditure devoted to sheriff, con-

[41] In each case compensation insurance and "outlays" (Appendix A, page 102) make up the remainder of the expenditure for protection to persons and property. See table 18.

stables, and jails in the smaller counties shows that it is the expenditure for support of the statutory office of sheriff which is chiefly responsible. Counties in group I expend 38.4 per cent of the total for protection to

DISTRIBUTION OF EXPENDITURE FOR PROTECTION TO PERSONS AND PROPERTY BETWEEN THE SHERIFF AND RELATED SERVICES AND SERVICES TO ECONOMIC WELFARE, BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

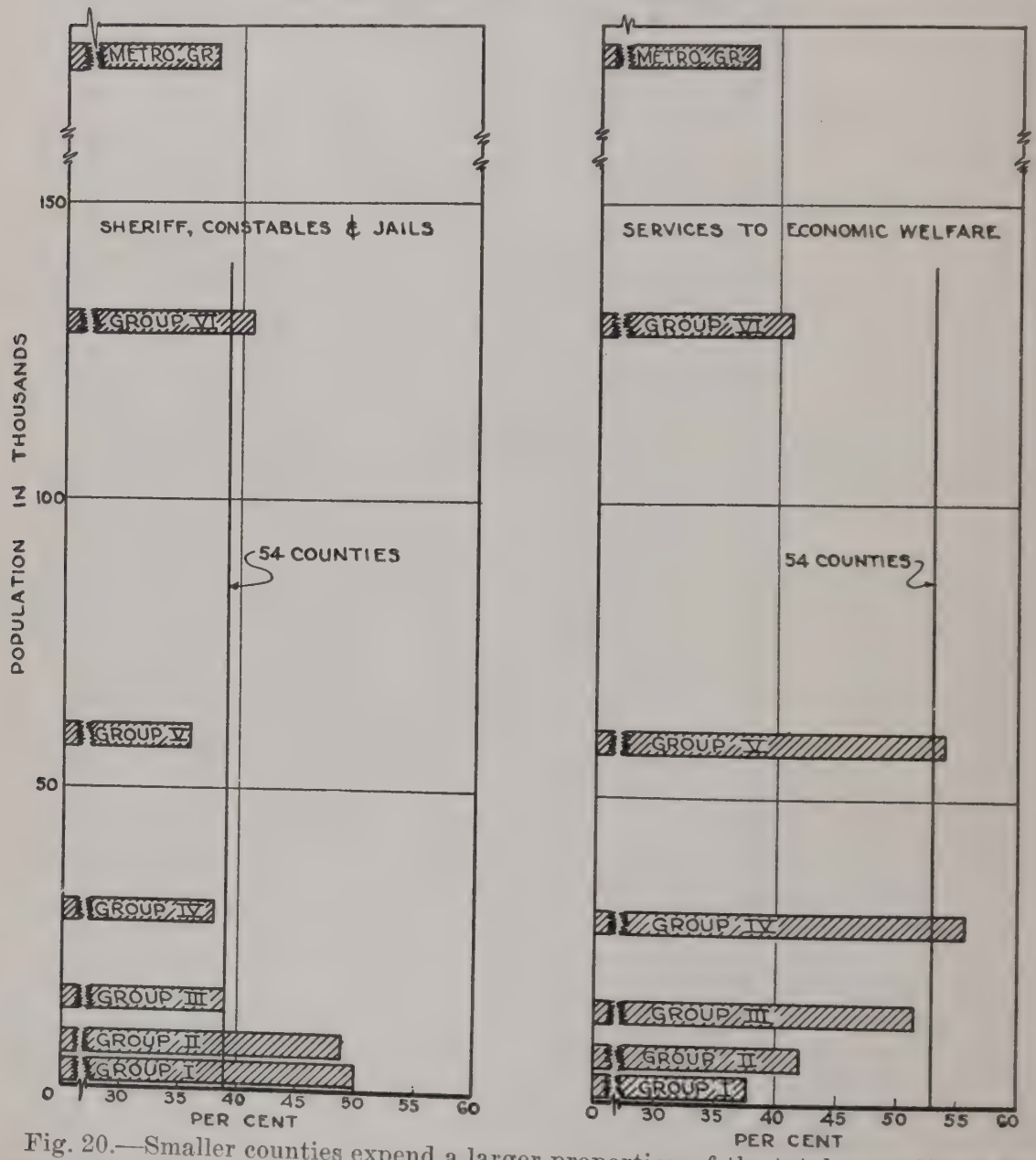


Fig. 20.—Smaller counties expend a larger proportion of the total expenditure for protection to persons and property for the support of the sheriff, constables, and jails than do the counties of medium and larger size. The varied services to economic welfare command the largest share of the total in the medium-sized counties. (Data from table 18.)

persons and property for the support of this office, which amounts to a per-capita expenditure of $1.68. A steady decline in this proportion is observed in passing to the larger counties until group IV is reached

with but 19.4 per cent of the total expenditure for this office. Likewise there is a drop in the per-capita expenditure for the sheriff in group IV to less than one-third of that expended by counties in group I and to but little over a half of that expended by group II. It is interesting to note that in the case of the two largest groups, expenditure for law enforcement, particularly for the sheriff, tends to regain some of the importance in comparison with total expenditure that it has in the very small counties.

TABLE 19

Expenditure for Protection to Persons and Property by Major Divisions*
Average Annual 1929–30 to 1931–32

County group	Sheriff, constables, and jails			Services for economic welfare		
	Amount	Per cent of total for protection to persons and property	Per capita	Amount	Per cent of total for protection to persons and property	Per capita
Group I	$ 32,359	49.9	$2.19	$ 24,423	37.7	$1.65
Group II	98,089	49.1	1.59	84,587	42.3	1.37
Group III	181,663	38.9	1.43	241,806	51.7	1.91
Group IV	297,058	38.3	1.05	431,499	55.7	1.52
Group V	689,145	35.9	0.97	1,035,851	53.9	1.45
Group VI	868,704	41.2	0.91	1,122,520	53.3	1.18
54 counties	2,167,018	39.1	1.01	2,940,686	53.1	1.37
Metropolitan group	2,901,866	38.1	1.00	2,813,096	36.9	0.97
All counties†	$5,068,884	38.5	$1.00	$5,753,782	43.7	$1.14

* Compensation insurance and "outlays" are not included under either division in this table, although they comprise a part of the expenditure for protection to persons and property in the State Controller's classification followed here.

† Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

With the high proportion of protection-to-persons-and-property expenditure for the statutory office of sheriff in the smaller counties, there is naturally a correspondingly lower proportion of expenditures for certain of the services to economic welfare.

Since the office of *recorder* among the latter is a statutory one, previous experience would not indicate that there would be a lower proportion of protection-to-persons-and-property expenditure for this item in the smaller counties. Examination of table 18 shows that such expectations are sustained in part at least. The smaller county groups in the main spend a slightly higher proportion of their total protection-to-persons-and-property expenditure for the services of recorder, and the per-capita expenditure is of course definitely higher for the small counties. An interesting observation is that whereas in the larger counties (and for counties as a whole) the fees collected by the recorder for serv-

ices rendered[42] are generally equal or more than equal to the expenditure for this office, in the smaller counties the expenditure generally outruns the collections. Once again we find an apt illustration of the statutory surplus of machinery in relation to business for the small county.

It is in the expenditure for *agricultural commissioner* and *farm advisor*[43] that the smaller counties compensate for the high proportion of expenditure for protection to persons and property devoted to the statutory functions, particularly the sheriff. For the 54 counties, expenditure for these services amounted to $1,260,028, or nearly 23 per cent of the total for protection to persons and property—equivalent to a per-capita expenditure of $0.59. The counties in group I expended but 6.1 per cent for such services[44] and those in group II but 13.7 per cent. A further increase in proportion of the total for these services occurs with group III, and a per-capita peak of $0.79 per capita is reached. This group, containing a number of the smaller valley counties, is the first among the various groups to undertake a reasonably complete provision of farm advisor and commissioner services. In comparison with the larger counties the comparatively small number of people supporting these services in this group of counties results in a relatively high per-capita expenditure. With group IV and group V the proportion of expenditure for agricultural commissioner and farm advisor comes to exceed one-quarter of the total expenditure for protection to persons and property. For these counties it thus becomes the largest of the individual items in table 18, although the per-capita levels remain below that of group III. From group V there is a decline in both the proportion of all expenditure and in the per-capita levels for farm advisor and agricultural commissioner.

The 54 counties expend $1,056,811, or 19.1 per cent of the protection-

[42] Disregard of the sources of expenditure has been a necessary policy in connection with this study so that it might be kept within manageable proportions. Where fees are collected to cover the services rendered, this narrowing of the field causes some logical difficulty, most apparent in the case of the recorder, but also of some significance for the county clerk, the justices of the peace, and, to a very minor degree, in the case of the sheriff.

[43] The policy of the Office of the State Controller in compiling data on the financial transactions of counties has been to keep as constant as possible the manner of compilation and presentation in order to enhance the value of year-to-year comparisons. From the standpoint of statistical use, such a policy is wholly justifiable, but substantial improvements might be made without loss of time-series value. The combination of expenditure for farm advisor and horticultural commissioner is a case in point. By combining these two very considerable items of expenditure in the State Controller's reports, the possibility of gaining statistical information about either is completely removed. Separate presentation, on the other hand, would destroy none of the year-to-year comparability while adding this new information with respect to the expenditures in question.

[44] As a matter of fact but one county (Del Norte) in this group undertakes to provide for farm advisor services and that in coöperation with a neighboring county.

to-persons-and-property total for the services listed in table 18 as *inspection services, game and fire protection, bounties, etc.* In detail, this covers the inspection of livestock, bees, oil wells, weights and measures, together with forest and fire protection, bounties on predatory animals, and provision for the services of public administrator[45] and game warden. Counties in the two smallest population groups spend a somewhat smaller proportion of the total for these services although the per-capita levels are above those of the 54 counties. The variety of these services in the smaller counties is also somewhat more limited than in the medium-sized and larger counties.

As a general conclusion to the examination of expenditure for protection to persons and property it may be noted that the smaller counties devote the major portion of expenditure under this heading to the statutory and traditional offices. Once again there is considerable evidence of unused overhead in these offices in the smaller counties. In the larger counties, expenditures for statutory offices shrink in relative importance, while services to the economic life of the county are increased in quantity and multiplied in variety. It is to be granted, of course, that many of these latter services might not be justified in the types of counties that are included in the smaller population groups. The weight of expenditure for the statutory and traditional county functions in the smaller counties indicates, however, that this is the really important reason for the elimination of other services together with difficulty in providing certain of them for very small units. In any case, it is unfortunate that the smaller counties, though not getting the same volume of services as the larger, should be paying about as much per capita.

EXPENDITURE FOR HEALTH AND SANITATION[46]

The expenditure for health and sanitation covers support of the health officer, expenditure for control of contagious disease, eradication of disease carriers, sanitary inspection, compilation of vital statistics, and a few other relatively minor functions of similar character. For the 54 counties during the period 1929–30 to 1931–32, these expenditures amounted to an average of $1,935,074 or 1.6 per cent of the total expenditure—approximately one-third of that for protection to persons and property. For all counties the expenditure for protection of health was $5,007,561 or 1.9 per cent of the total (table 20). The position of this

[45] This office, involving an expenditure for most counties of a few hundred dollars annually, may appear out of place. Broadly speaking, however, it is a service to economic welfare and is conveniently included at this point.

[46] This expenditure represents the combination of two expenditure items as entered in the compilations of the State Controller. These are "conservation of health" and "sanitation and promotion of cleanliness."

TABLE 20

AMOUNT, PER CENT OF ALL EXPENDITURES, AND PER-CAPITA LEVELS OF EXPENDITURE FOR HEALTH AND SANITATION BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

Counties and groups of counties	Amount	Per cent of all expenditures	Per capita	Counties and groups of counties	Amount	Per cent of all expenditures	Per capita
Group I, 0-5,000	$ 2,485	0.2	$0.17	Butte	$ 9,333	0.5	$0.27
Alpine	104	0.3	0.31	Merced	129,520	5.6	3.52
Mono	5	*	*	Santa Cruz	9,738	0.5	0.26
Sierra	162	0.1	0.07				
Trinity	459	0.3	0.16	Group V, 40,000-80,000	686,357	1.7	0.96
Mariposa	265	0.1	0.08	Solano	19,453	1.2	0.48
Del Norte	1,490	0.3	0.31	Marin	42,923	2.0	1.03
				Humboldt	66,784	2.8	1.54
Group II, 5,000-10,000	30,662	0.8	0.50	Monterey	30,467	0.9	0.57
Calaveras	1,880	0.5	0.71	Ventura	42,745	1.1	0.78
Inyo	1,274	0.3	0.19	Stanislaus	56,147	1.9	0.99
Lake	2,373	0.4	0.33	Imperial	10,952	0.4	0.18
Plumas	5,052	0.9	0.64	Sonoma	9,354	0.3	0.15
Modoc	1,040	0.2	0.13	Santa Barbara	47,352	1.0	0.72
El Dorado	4,759	1.1	0.57	San Mateo	199,003	5.3	2.57
Amador	5,594	1.7	0.62	Tulare	83,761	2.1	1.08
Tuolumne	8,690	1.6	0.94	Contra Costa	77,416	1.6	0.99
Group III, 10,000-20,000	90,304	1.1	0.71	Group VI, 80,000 and over	815,486	1.6	0.86
Colusa	9,587	1.1	0.93	Riverside	27,303	0.6	0.34
Nevada	3,060	0.7	0.29	Kern	156,275	2.4	1.89
Glenn	869	0.1	0.08	San Joaquin	253,794	4.9	2.47
San Benito	12,814	2.1	1.13	Orange	69,785	0.9	0.59
Yuba	11,155	1.4	0.98	San Bernardino	12,802	0.2	0.10
Lassen	945	0.1	0.08	Sacramento	141,054	2.3	0.99
Tehama	5,327	0.6	0.38	Fresno	121,741	1.6	0 84
Shasta	2,332	0.3	0.17	Santa Clara	32,732	0.5	0.23
Sutter	8,358	0.8	0.57				
Madera	35,857	3.5	2.09	Total, 54 counties	1,935,074	1.6	0.90
Group IV, 20,000-40,000	309,780	2.0	1.09	Metropolitan group	3,072,487	2.1	1.06
Napa	5,819	0.5	0.25	San Diego	138,388	1.3	0.66
Mendocino	2,366	0.2	0.01	Alameda	271,391	1.4	0.57
Yolo	33,183	2.3	1.40	Los Angeles	2,662,708	2.2	1.21
Placer	23,163	2.1	0.95				
Kings	23,900	1.7	0.94	Total, all counties†	$ 5,007,561	1 9	$0 99
Siskiyou	609	*	0 02				
San Luis Obispo	$ 72,149	3 4	$2 44				

* Less than 0.1 per cent.

† Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

expenditure in the general total may be visualized by comparison of the $0.90 per capita involved for the 54 counties with the per-capita expenditure for all functions of $55.46.

Although a relatively minor item, the place of expenditure for health

services is by no means similar for all counties. In fact, this expenditure in contrast with almost all of those so far considered shows a marked increase in comparative per-capita levels in passing from the very small to the medium and large counties. The amount expended for health services by counties in group I is virtually nominal, amounting to but 0.2 per cent of the total expenditure and a per capita of $0.17. Counties in group II likewise show a very small expenditure for this service, although the proportion of the total expenditure shows an increase to 0.8 per cent with a per capita of $0.50. Counties in group III and group IV show further increases both in the proportion of the total budget devoted to this item and in the per-capita levels. The 2.0 per cent of the total devoted to health by counties in group IV, amounting to a per-capita expenditure of $1.09, represents a peak among the various groups.

While there is much variation in the per-capita levels of expenditure and in the proportion of the total expenditure devoted to health services, there is no doubt of the marked increase from the small to the medium-sized and larger counties. The most obvious, and probably most important factor basic to this higher expenditure by the larger counties is that many of the health services have been added to the list of county activities in comparatively recent times and as a result of a fairly modern concern for matters pertaining to public health. This latter is especially true in the rural areas. The counties which support health services are those whose budgets have not been overstrained by the traditional and statutory county services, or, in short, the large counties. Here is an example of an entire function being crowded from the budget and services of the smaller counties. There can be little doubt, however, that the need for certain of the health services here included is more acute in the very populous counties than in those of more sparse settlement.

RECREATIONAL AND MISCELLANEOUS EXPENDITURES

Expenditures for recreation and for miscellaneous county functions are not wholly susceptible to statistical appraisal of the present order. The first of these items, covering expenditure for purchase and maintenance of parks and support of museums, art galleries, and celebrations, amounted to an average of $737,830 or 0.6 per cent of the total expenditure of the 54 counties (table 8). The metropolitan counties expended 1.0 per cent of their collective total for this function bringing the all-county expenditure to $2,178,372 or 0.8 per cent of the total expenditure. There is, however, a relatively large variation of the proportion of the total and comparative levels of this expenditure from county to county. Moreover, the expenditure is not sufficiently large but

that individual county expenditures of special character unduly influence group levels even through the three-year average. Save to note the place of recreational expenditure in the expenditure situation as a whole, this item may be passed by from the standpoint of present interest.

The same situation obtains in a general way for miscellaneous expenditures. Surprisingly small as a group, considering the ordinary possibilities of such a classification, these cover county advertising (other than that of an official character), county exhibits, payments for correction of errors, and a number of smaller items. For the 54 counties, miscellaneous expenditure amounted to $1,406,362 or 1.2 per cent of the total expenditure for the average of the three years considered (table 8). All counties expended $4,064,919 or 1.5 per cent of the total. While the variation from county to county is not as great in the case of this item as in the case of expenditure for recreation, it is none the less considerable. There is evidence of a somewhat higher proportion of the total as well as per-capita expenditure on the part of the very small counties. More definite, however, is the higher expenditure by the very large counties, particularly under the influence of expenditure for exhibits and advertising.

EXPENDITURE FOR SERVICE ON INDEBTEDNESS[47]

While, as shown under "Historical Analysis of County Expenditures," there is some danger of overestimating the role of interest payments in the increase in county expenditure over the last decade and a half, the burden of past borrowing does not rest lightly on the combined budgets of California counties. The 54 California counties expended for service on the indebtedness (combining payments on interest and principal)[48] an average of $12,771,936 for the three years here considered (table 21). This sum, equivalent to 10.7 per cent of the total expenditure, ranked third among the other expenditure groups, exceeded only by education and highways. For all counties of the state, service on indebtedness amounted to $29,730,728 or 11.1 per cent of the total expenditure—just enough, when considered in this way, to displace charities and corrections from second place among the various expenditure groups.

The variation in proportion and comparative, or per-capita, levels of

[47] Expenditure for service on indebtedness, as in the case (most notably) of expenditure for education, includes the expenditures of certain types of districts logically included in the study (page 105). The data available for the analysis of these district expenditures for indebtedness are perhaps the least satisfactory, in point of detailed accuracy, of any here employed. They do serve, however, to give a reasonably satisfactory picture of those broader outlines of the expenditures which are in keeping with the objectives of the present study. The nature and limitations of these data as well as the types of districts included are discussed in detail in Appendix A, page 105.

[48] See Appendix B, page 108.

expenditure between small and large counties, at this stage anticipated almost as a matter of course, is not lacking in the case of service on indebtedness. The trend, however, with respect to comparative levels is, as in the case of health expenditures, definitely the reverse of that apparent for most of the other expenditure groups. From table 21 and figure 21 it is apparent that the large county and not the small one is shouldering and paying for the largest proportion of indebtedness in comparison with current expenditure and population. From the 3.4 per cent of all

TABLE 21

Total Expenditure for Service on Indebtedness by County Groups, Average Annual 1929–30 to 1931–32

County group	Amount	Per cent of total expenditure	Per capita
Group I	$ 40,592	3.4	$2.73
Group II	161,295	4.3	2.61
Group III	734,476	9.1	3.81
Group IV	1,709,720	10.8	6.04
Group V	4,506,259	11.4	6.32
Group VI	5,619,591	10.9	5.91
54 counties	12,771,936	10.7	5.94
Metropolitan group	16,958,792	11.3	5.86
All counties*	$29,730,728	11.1	$5.89

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

expenditures devoted to debt service by counties in group I, there is an increase by nearly 1 per cent to group II, and the proportion expended by the latter group is more than doubled in passing to group III. Counties in group IV, standing at about the average for all counties, expend more than three times as great a proportion of all expenditures for service on indebtedness as do counties in group I, and more than two and one-half times as high a proportion as counties in group II. From this point, however, there is a less noticeable change. The group V counties show an increase of 0.6 per cent in the proportion of total for debt service over group IV to the high point for the various county groups. There is a slight decline in the proportion for group VI with another increase for the metropolitan counties.

Since the smaller counties have a considerably higher per-capita total expenditure than the larger,[49] the difference in per-capita levels for

[49] Pages 35 to 39. With respect to the use of per-capita figures as a basis of comparing volume of expenditure for service on indebtedness, the dominant position of school construction as the original subject of this expenditure has already been noted. From this standpoint, and within the limits previously established, per-capita figures are a valid basis for comparing the volume of expenditure for different counties.

service on indebtedness between small and large counties is less marked than that of percentage or proportion of total expenditure. The contrast, however, is none the less considerable. From a per-capita level of $2.73 for group I there is a decrease of $0.12 to $2.61 for group II, and

COMPARATIVE PER-CAPITA EXPENDITURE AND PROPORTION OF ALL EXPENDITURE FOR SERVICE ON INDEBTEDNESS BY GROUPS OF CALIFORNIA COUNTIES, AVERAGE ANNUAL 1929–30 TO 1931–32

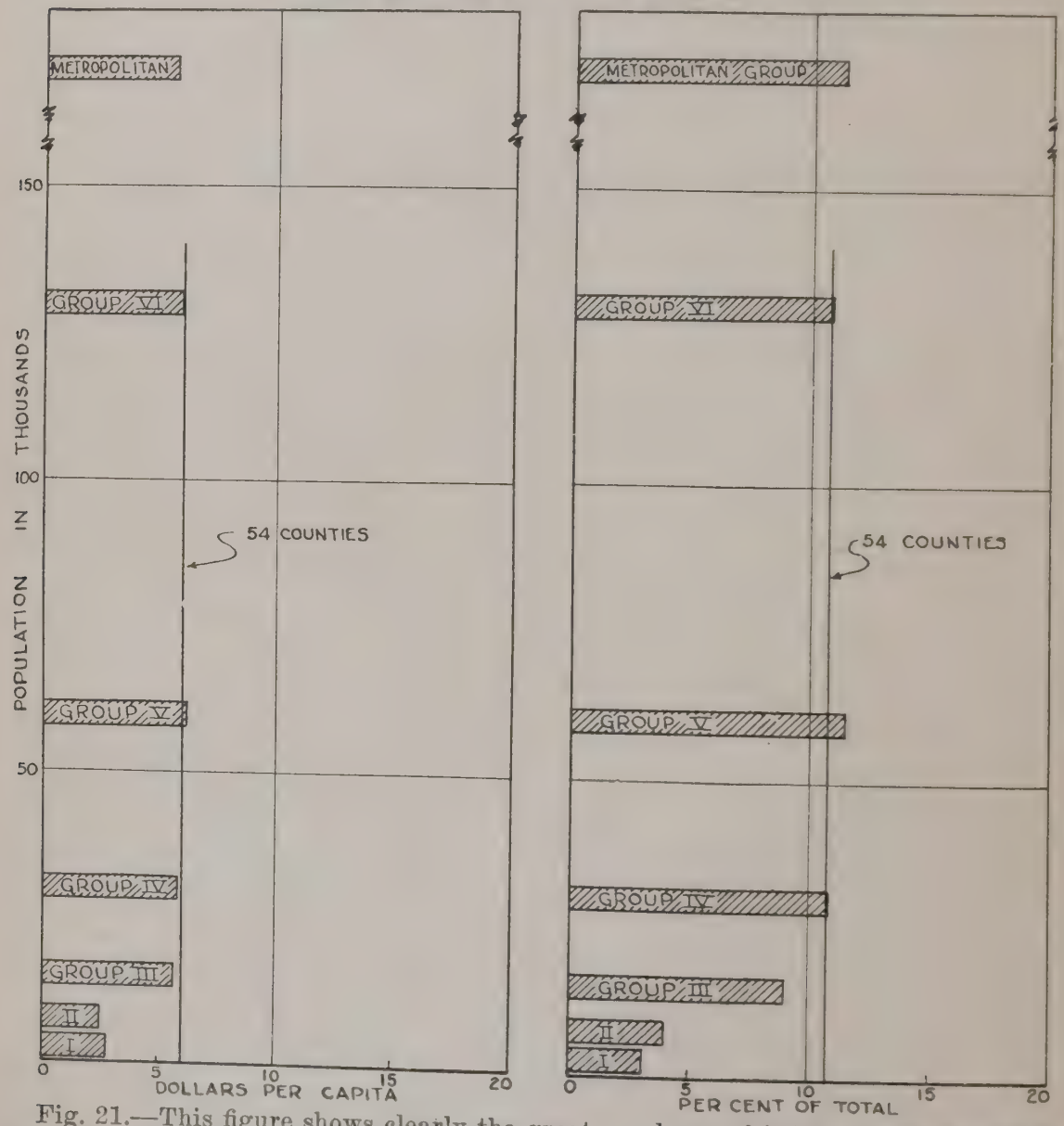


Fig. 21.—This figure shows clearly the greater volume of indebtedness supported by the larger counties. In both proportion of all expenditure and in per-capita levels a marked increase in expenditure for service on indebtedness is seen in passing from the smaller to the larger counties. (Data from table 21.)

then an unbroken increase up to $6.32 for group V. In other words, counties in group V spend considerably more than twice as much per capita as counties in either group I or II. For group VI a slight decline in per-capita levels to $5.91 corresponds closely to the per-capita level for the metropolitan group and for the 54 counties.

TABLE 22

Interest Payment by County Groups for County and District Bonds, Average Annual 1929–30 to 1931–32

County group	Interest on county bonds			Interest on district bonds			Combined interest on county and district bonds		
	Amount	Per cent of total expenditure	Per capita	Amount	Per cent of total expenditure	Per capita	Amount	Per cent of total expenditure	Per capita
Group I	$ 6,123	0.5	$0.41	$ 7,603	0.7	$0.51	$ 13,726	1.2	$0 92
Group II	19,450	0.5	0.31	55,478	1.5	0.90	74,928	2.0	1.21
Group III	124,094	1.5	0.98	208,370	2.6	1.65	332,464	4 1	2.63
Group IV	265,997	1.7	0.94	526,059	3.3	1.86	792,056	5.0	2.80
Group V	639,391	1.6	0.90	1,479,338	3.8	2.07	2,118,729	5.4	2.97
Group VI	549,351	1.1	0.58	2,071,168	4.0	2.18	2,620,519	5.1	2.76
54 counties	1,604,409	1.4	0.75	4,348,016	3.6	2.02	5,952,425	5.0	2.77
Metropolitan group	733,291	0.5	0.25	8,667,264	5 8	3.00	9,400,555	6.3	3 25
All counties*	$2,337,700	0.9	$0.46	$13,015,280	4.8	$2.58	$15,352,980	5 7	$3.04

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions"

For the 54 counties, expenditure for redemption of indebtedness was the heavier of the two charges coming under service on indebtedness. This amounted to $6,819,511 or 5.7 per cent of the total expenditure as compared with $5,952,425 or 5.0 per cent for payment of interest (tables 22 and 23). All counties, however, show the reverse of this relation with an expenditure of $14,377,748 or 5.4 per cent for redemption and $15,352,980 or 5.7 per cent for interest. In both cases it will be noted that payments for interest and redemption ranged between 5 and 6 per cent of the total expenditure.

Some note has already been made of the importance of district expenditure in the total disbursement for service on indebtedness. For the 54 counties, payment of interest on district indebtedness amounted to $4,348,016 or 3.6 per cent of the expenditure total as compared with $1,604,409 or 1.4 per cent for interest on county bonds (table 22). For all counties the proportion of expenditure for district indebtedness was even greater, amounting to 4.8 per cent of the total county expenditure as compared with 0.9 per cent for county indebtedness. Likewise, in the case of redemption of indebtedness for the 54 counties, district expenditure amounted to $4,899,432 or 4.1 per cent of the total expenditure, while retirement of county indebtedness accounted for but $1,920,079 or 1.6 per cent (table 23). All counties expended 4.3 per cent of their expenditure total for redemption of district bonds as compared with 1.1 per cent for county indebtedness. For debt service as a whole for the 54 counties, district indebtedness accounted for $9,247,448 or 7.7 per cent of the total expenditure as compared with $3,524,488 or 3.0 per cent for county indebtedness. All counties expended 9.1 per cent of their total disbursements for service on district indebtedness as compared with 2.0 per cent for that of the county as a whole.

The relation between district and county expenditure for the service on indebtedness as above cited does not, however, hold constant for all counties (tables 22 and 23). There is a definite tendency for the smaller counties to show a higher ratio of county to district expenditure both for payment of interest and redemption of debt. For group I the expenditure for service on county indebtedness amounted to 2.0 per cent of the total expenditure for the group as compared with 1.5 per cent for district indebtedness. For group II there is a reversal in the position of these two items with county indebtedness accounting for but 1.2 per cent of the total as compared with 3.1 per cent for district indebtedness. Continuing to group III, service on county bonds accounts for 3.1 per cent of the total expenditure as compared with 6.0 per cent for district indebtedness.

From group III through the larger groups it is difficult to detect any

TABLE 23

Debt Redemption by County Groups for County and District Bonds, Average Annual 1929–30 to 1931–32

County group	Redemption of county bonds			Redemption of district bonds			Combined redemption of county and district bonds		
	Amount	Per cent of total expenditure	Per capita	Amount	Per cent of total expenditure	Per capita	Amount	Per cent of total expenditure	Per capita
Group I	$ 17,066	1.5	$1.15	$ 9,800	0.8	$0.66	$ 26,866	2.3	$1.81
Group II	26,000	0.7	0.42	60,367	1.6	0.98	86,367	2.3	1.40
Group III	127,475	1.6	1.01	274,537	3.4	2.17	402,012	5.0	3.18
Group IV	354,096	2.2	1.25	563,568	3.6	1.99	917,664	5.8	3.24
Group V	754,942	1.9	1.06	1,632,588	4.1	2.29	2,387,530	6.0	3.35
Group VI	640,500	1.2	0.67	2,358,572	4.6	2 48	2,999,072	5.8	3.15
54 counties	1,920,079	1.6	0.89	4,899,432	4.1	2.28	6,819,511	5.7	3.17
Metropolitan group	927,333	0.6	0.32	6,630,904	4.4	2.29	7,558,237	5.0	2.61
All counties*	$2,847,412	1.1	$0.56	$11,530,336	4.3	$2 29	$14,377,748	5.4	$2.85

* Excluding City and County of San Francisco.

Source of data: Computations by author based on "Financial transactions."

consistent tendency towards increase either in the proportion of the total expenditure devoted to the service on county indebtedness or in the comparative levels of this disbursement. It is true that counties in group IV expend 3.9 per cent of their total disbursements for service on county indebtedness or an increase of 0.8 per cent and $0.20 per capita over group III. Counties in groups V and VI, however, as well as the metropolitan counties, show actual decreases in both the proportion of the total expenditure devoted to service on county indebtedness and in the per-capita levels of this expenditure.

Expenditure for service on district indebtedness, on the other hand, shows a steady and consistent increase throughout the entire range of county groups. Group IV shows an increase of 0.9 per cent in the proportion of the total devoted to this item over group III and also a small increase in per-capita expenditure. Further and even sharper increases are apparent throughout the remaining groups, bringing the proportion of total expenditure for service on district indebtedness to 7.9 per cent of the total expenditure for group V and to 8.6 per cent for group VI or, in the case of this last group, nearly four times the expenditure for service on county indebtedness.

In turning now to a broader view and appraisal of the expenditure for service on indebtedness as just outlined, it is well to recall two rather obvious facts in connection with public borrowing. The level of indebtedness of a local unit of government, unhampered in this regard by constitutional restriction of such stringency as to become a barrier to popular impulse, is, in the main, dependent on two things. The first of these is the demand for the subject of the expenditure in question, whether rational or otherwise, and tempered by the necessity of subsequent repayment. That this demand is often created by an active minority which stands to profit substantially by the expenditure is important but does not contradict the general proposition. The second factor determining the level of indebtedness is the ease or difficulty with which money is obtained. That the two operate together is of course apparent when it is considered that difficulty of borrowing may reflect through increased interest rate or disutility of repayment.

During most of the period when counties were borrowing the funds upon which service is now being paid, it is difficult to concede that the item of finding an investor was a particularly important problem for the county, large or small. Subject perhaps to a slight interest-rate differential, the small county could place its loans, if not at will, certainly within the bounds of desired borrowing. This would imply that the limiting factor is more likely to be the first mentioned of the factors above cited, i. e., the demand on the part of the unit in question for the subject

of the expenditure as measured against the necessity for repayment with interest.

Further indication that the above is the case grows out of the fact that a large portion of the increase from the smaller to the larger counties in expenditure for service on indebtedness is for district indebtedness. As measured by volume of expenditure for service on indebtedness, school districts are by far the most important types here included (see following paragraph). The increasing proportion of total expenditure for support of schools, in passing from the smaller to the larger counties, has already been pointed out (page 42). As might well be expected, this is accompanied by more elaborate school buildings in the larger counties, which are reflected in turn in the higher bonded indebtedness of school districts upon which the costs of school construction fall. This, combined with perhaps slightly greater faculty for borrowing by districts in the larger counties, is unquestionably the dominant factor in the higher levels of expenditure for interest on indebtedness.

While this higher district expenditure for service on indebtedness incurred for school construction appears responsible for the major part of the higher levels of expenditure for this item in the larger county, there are also contributory items which should not be overlooked. The larger counties have apparently deemed necessary, or demanded, the provision of a considerable variety of other services requiring that district indebtedness be incurred. District organization for road improvement is of chief importance in the larger counties and accounts for a small portion of the higher levels for service on indebtedness in these counties. The same is true (although the restriction to the larger counties is somewhat less marked) for fire prevention, lighting, flood control, and drainage and storm-water removal.[50] While some of these may be more closely related to the virtually inescapable needs of the more populous community, others are distinctly services which any county, large or small, might undertake to provide for itself with fulfillment of an equivalent want on the part of its residents.

[50] The combined expenditure of these for service on indebtedness, however, is relatively minor in comparison with expenditure for service on indebtedness on school bonds. The shortage of satisfactory data may be partially overcome by examination of the data on tax collections. In 1932–33 approximately 18.7 million dollars were collected for service on elementary and high school bonds according to the State Controller's data. Service on indebtedness on junior college bonds accounts for perhaps 0.5 to 1.0 million dollars. Total expenditures for service on district indebtedness were approximately 24.5 million, indicating that for all counties combined the variety of districts (other than school) here included expended between 4 and 5 million dollars for service on district indebtedness. Expenditures of Los Angeles County for service on indebtedness of districts other than for school purposes are especially heavy. When the 54 counties are considered, the proportion for miscellaneous district debt service is somewhat smaller. ("Financial transactions." p. 228. 1932–33.)

Levels of district indebtedness for schools and for other purposes are thus indicative of services performed. It well may be that there is here another case of the limitation of services performed in the smaller counties through the choking of demand for them by the higher levels of expenditure for maintaining the administrative machinery and traditional and statutory officers and functions. The county which is out of debt or has a low level of bonded indebtedness is probably justified in considering itself fortunate, other things being equal. Other things are not equal, however, if the bonded indebtedness was kept low because the high levels of expenditure for the more rudimentary county functions and services throttled any thought of adding service on indebtedness to the total.

EXPENDITURE REFORM

Reduction of expenditure has already been mentioned as one of the two avenues by which the distressed taxpayer looks for escape from his tax burden. However, the suggested ways and means of effecting expenditure reduction have been exceedingly numerous in recent years. At this stage in the survey of county expenditures, it is possible to appraise the results and consequences of certain of the suggested means of effecting tax relief through expenditure reduction.

RETRENCHMENT IN EXPENDITURE

Straightforward reduction of expenditures, and thereby taxes, by the simple expedient of spending less money has, for reasons that are more than obvious, always had a definite appeal as an escape from problems of high taxation. If both people and government are prepared to accept the consequences, no amount of argument can hide the fact that expenditures can be reduced in this way. A sane and realistic view of this method of reducing expenditures, however, does take into consideration the consequences. When this is done the problem no longer remains a simple one.

The consequences of expenditure reduction, particularly as they relate to the services performed by the government, vary with the government in question, the amount of the reduction, and the care with which the reduction is effected. Most favorable among the possible consequences of expenditure reduction is an increase in efficiency with which the services are performed and with no impairment in the services. This is the type of expenditure reduction most frequently discussed by candidates for public office, although the rarity with which it is effected suggests its illusory character. In recent years reduction of salaries to levels in keeping with wage scales and prices generally prevailing has been the most important method of effecting economy without curtailment of services.

Next along a scale measuring the importance of the consequences of

expenditure reduction is that reduction which involves the trimming away of the less important or so-called "nonessential" services. Expenditure reduction through elimination of the nonessential services has also received both political and popular acclaim in recent years. Statement of the actual services considered nonessential frequently has been lacking. When such statement has been made it has often revealed marked and militant differences of opinion.

Still more deep-seated are the consequences of expenditure reduction which involves the curtailment or elimination of universally valued services. When the consequences are of this character it is, of course, unnecessary to say that the problems of expenditure reduction differ markedly from those when no such curtailment or elimination is involved.

Finally, there are reductions in expenditure which might affect what are generally referred to as the uncontrollable expenditures—expenditures which in large part are either required by law or represent the fulfillment of pledges of the government in question. Few governments choose to consider or accept the consequences of expenditure reduction which results in outright violation of the law or the breaking of pledges to redeem their borrowings.

In the case of the California county, there is yet a fifth type of expenditure reduction, not entirely parallel with those above mentioned. This reduction, if effected, would merely result in the saving of funds coming from the state without effecting reduction in county taxes. Since these funds are earmarked for specific purposes, reduction in expenditure of funds from such sources is seldom even seriously considered.

In determining the extent to which California county expenditures might conceivably be reduced and the consequences of varying degrees of reduction, expenditures of the last two classes above mentioned may be first set aside as more or less incapable of any reduction. For the 54 counties, the average total of the state apportionment for various purposes for the three years 1929–30 to 1931–32 was approximately $21,200,000.[51] The matching of school funds then required by law, and which funds are now also provided by the state, amounted to an additional $15,800,000, bringing the total of the expenditure thus fixed to approximately $37,000,000 out of the total expenditure of the 54 counties of $119,243,368. For all counties (including Los Angeles, Alameda, and San Diego) the total state apportionment amounted to approximately $75,700,000 out of $269,033,583. This is the portion of the expenditure which, on the basis of present conditions, is not provided directly by the people of the county.

[51] Computations by author based on "Financial transactions."

Expenditures for interest and for redemption of indebtedness amounted to an average of $12,772,000 for the 54 counties, bringing the total of the fixed expenditures to nearly $50,000,000 for the average of the three years. Similarly, out of the $269,033,583 expended by all counties, the fixed expenditures amounted to approximately $105,431,000.

Broadly speaking, the remaining $69,000,000, approximated for the 54 counties, and $164,000,000 for all counties represent the controllable element in county expenditure. This is only true in a formal sense, for it does not appear that the responsibilities involved in such an expenditure as charities and corrections are less important than in the case of expenditure for service on indebtedness.

The proportion of the remaining expenditure necessary for the adequate support of essential services and that which supports nonessential services and functions is of course impossible of determination. Examination of the distribution of expenditures shows that, with the exception of the very small counties, the large proportion is for services that this unit of government is definitely expected to perform. Likewise, the increase in recent years has been greatest for those services generally recognized as being in popular demand. To classify certain of these as nonessential would be, of course, almost completely arbitrary.

From another viewpoint, however, it may be noted that average expenditures, for the three years 1929–30 to 1931–32, were actually somewhat above the expenditures for the fiscal year 1929–30. If, with the wage scales and levels of payments prevailing generally in 1929, it was possible to obtain a given level of service, there is, of course, no reason why the same services might not be achieved at a considerably lower level in succeeding years, provided that county wage scales and levels of payments were kept in close adjustment with those prevailing elsewhere. In 1930–31 and 1931–32, county expenditures were considerably out of adjustment with price payments generally.[52] It seems certain that wage scales which lagged considerably behind those in effect elsewhere were largely responsible.

Of the possibilities of lowered expenditure through increased efficiency, and without curtailment of services, the study gives definite indication particularly for certain groups of counties. Mention and appraisal of these possibilities is the task of sections immediately following.

[52] Galbraith, J. K. California county expenditures. An analysis of the trends and variations between counties for county services and functions. p. 21–32. Thesis for the degree of Doctor of Philosophy, University of California, May, 1934. (Typewritten.) Copies on file in the University of California Library and the Giannini Foundation Library, Berkeley.

COUNTY REORGANIZATION

Reorganization of the political and administrative structure of the county has been an established recommendation of careful students of local government in California for many years. Few have undertaken to argue against the advantages of simplification and integration, together with increased responsibility in the machinery of county government. Only the inertia in such matters, coupled with the influence of those who have certain advantages vested in the present system, and perhaps the errors of overzealous reformers, have prevented a much more general revamping of the governmental machinery in individual counties than has so far taken place.

In general, it has been the larger counties of the state which have found the dictated organization under general laws and tradition most seriously deficient. In particular, it has been these counties that have moved towards the adoption of home-rule charters with promise of some measure of reform. The present study is not of such character as to bring conclusive evidence to bear on the need of reorganization in the larger counties. It is strikingly apparent, however, that the general law and traditional organization can scarcely be more unsatisfactory for the large and populous units than it is for the very small county. A type of organization which takes from 10 to 25 per cent of all expenditures for the largely "overhead" cost of general government and a comparably heavy proportion for other functions fixed by statute; which gives evidence of definite lack of efficiency in the system of highway and institutional administration; which leaves the county relatively barren of services beyond those of the most time-honored character; and which shows, withal, a higher rather than a lower level of expenditures than in the case of other counties, is certainly to be condemned. There can be no doubt but that much difficulty will always be experienced in providing ecenomical government with its services for the very small county.[53]

At present, however, besides providing government for the very small county, an effort is being made to provide it with the same form and, from the standpoint of statutory functions, with something approaching the same scale as for the much larger counties.

The practical difficulties involved in county consolidation are well recognized. It may be that these difficulties can be circumvented by stressing instead the internal simplification of the government of the small county through much further consolidation of officers and functions than has yet occurred, the elimination of certain offices largely justified by tradition, the consolidation of road districts, and the per-

[53] This point of view is developed more fully in the succeeding section.

formance of certain services, particularly in the field of welfare, jointly with other counties. Almost all of these could be accomplished without further legislation and a number of them without even the need for adoption of a county home-rule charter. However, the possibilities of simplification and even drastic curtailment of the unused machinery for government in the very small counties through adoption of charters is an experiment which it is hoped will not be too long delayed.

CONSOLIDATION OF COUNTIES WITH SMALLER POPULATIONS

The economies possible from the consolidation of counties into units that are of a size deemed more in keeping with modern facilities for communication and transportation have been much discussed in recent years. For the smaller counties of California it is possible to throw considerable light on the nature and degree of these economies as a result of the comparison of expenditures for counties of various sizes as heretofore presented.

A number of plans for consolidating California counties have been suggested in recent times. One of these proposes the reduction of the number of counties from 58 to 15.[54] The general outlines of this plan (as modified for present purposes; see page 92) are shown in figure 22. It was released to the press with the following statement:

> In suggesting these divisions, it should be understood no hard and fast boundary lines are being drawn at this time, nor should we say definitely that 15 is the proper number of divisions.
>
> This should be studied carefully and consideration given to all of the various influences which are factors. It will be no easy task to redistrict the State into larger governmental districts into each of which several counties may be consolidated.
>
> Each new unit should have a general community interest and, where possible, an economic unity, with transportation facilities reaching into every part of the area.[55]

Five of the suggested new areas under this plan include 18 of the 22 smallest counties of the state and consolidate a total of 22 counties (table 24). Only 6 counties which come under groups I, II, and III are not included in one or another of these areas. The five areas as presented in the plan are described as follows:

> 10—North Sacramento Valley area: Red Bluff or Chico control city for northern Colusa, western Butte, Tehama, Glenn, and southern Shasta counties.
>
> 11—Redwood area: Eureka control city for Del Norte, Humboldt, Trinity, and northern Mendocino and western Siskiyou counties.
>
> * * * * * * * * *
>
> 13—Siskiyou Mountain area: No control center suggested, but area would include major portions of Siskiyou, Modoc, Lassen, Shasta, and part of Plumas.

[54] Suggested by Mr. Rolland A. Vandergrift. One of the most complete discussions of the plan will be found as a feature article in: The San Francisco Examiner. February 25, 1934, Sec. 1, p. 12.

[55] The San Francisco Examiner. February 25, 1934, Sec. 1, p. 12.

14—North Sierra area: No control center suggested, area embracing mountain sections of Plumas, Sierra, Butte, Nevada, and part of Placer and Yuba counties.

15—South Sierra area: No center suggested, area including southern mountain region of El Dorado, Alpine, Amador, Calaveras, Tuolumne, Mono, and northern part of Mariposa County.[56]

The plan as above described has been made the experimental basis for an appraisal of the economies from consolidating the smaller counties of

Suggested Areas Under a Plan for County Consolidation



Fig. 22.—The suggested reorganization of California counties is shown. The shaded portions indicate the counties included in the present appraisal of economies from county consolidation. Boundaries of these areas have been adjusted to coincide with present county boundaries. (Adapted from: The San Francisco Examiner. February 25, 1934, Sec. 1, p. 12.)

[56] The San Francisco Examiner. February 25, 1934, Sec. 1, p. 12.

the state. Its use here does not imply that it is of special merit in comparison with other suggested schemes. Nor is it implied that consolidation will or should be effected by a general revamping of county lines rather than by more gradual consolidation of pairs or groups of counties. This plan has been used here because it serves to establish the possibilities of a reasonably thorough-going consolidation of the smaller counties in so far as this can be done with information developed by the present study.

TABLE 24

SUGGESTED AREAS UNDER PLAN FOR COUNTY CONSOLIDATION* WITH CONSTITUENT COUNTIES AND POPULATION

New area with constituent counties	Population	New area with constituent counties	Population
North Sacramento area	69,152	North Sierra area	45,399
Colusa	10,258	Plumas	7,913
Glenn	10,935	Sierra	2,422
Tehama	13,866	Nevada	10,596
Butte	34,093	Placer	24,468
Redwood area	50,781	South Sierra area	36,932
Del Norte	4,739	El Dorado	8,325
Humboldt	43,233	Alpine	241
Trinity	2,809	Amador	8,494
		Calaveras	6,008
Siskiyou Mountain area	60,034	Tuolomne	9,271
Siskiyou	25,480	Mono	1,360
Modoc	8,038	Mariposa	3,233
Lassen	12,589		
Shasta	13,927		

* As modified. See below

Source of data:
Population from: United States Department of Commerce Bureau of the Census. Fifteenth Census of the United States, 1930. Population. Vol. 1:127-145. 1932.

In order to establish the population of the new areas as well as to compare their computed expenditures with those of the counties they include, boundaries of the new areas have been adjusted to coincide with present county lines. This has involved the allotting of all of Siskiyou and Shasta to the Siskiyou Mountain area, the allotting of all of Butte and Colusa to the north Sacramento area, and the making of the two Sierra areas conterminous in their western boundaries with the present western boundaries of the foothill counties. The shaded area in the map (fig. 22), which is the section subjected to this appraisal, shows the areas as modified. Table 24 gives the areas and their populations together with the counties of which they are comprised and the populations of these counties.

In computing the expenditures of the new areas those items of expenditure which do not show a categorical relation to the size of the county

have not been included. Thus an irregular expenditure like "general government buildings and outlays" has not been included nor has expenditure for services to health, which are so clearly related to a higher level of service in the larger counties. Expenditure for highways has been included but in a more or less tentative fashion because of the seemingly apparent relation of part of the higher levels for this item in the smaller counties to sparseness of settlement, isolation, and rugged topography. Educational expenditure, it will be recalled, shows a higher comparative, or per-capita, level for the very small counties, although occupying a smaller place in the budget as a whole. The higher comparative levels, however, appear to be so immediately related to the cost of carrying this service to a sparse population that this expenditure has not been included.[57] Expenditures for service on indebtedness are clearly meaningless in connection with the present analysis.

With the expenditures clearly related to the size of the unit once isolated, the next step has been to assign the consolidated area to the population group to which it would belong if it now existed as a single county. Thus, the north Sacramento area would become a member of group V (counties having populations from 40,000 to 80,000) as would also the other areas with exception of the south Sierra area which, with a population of 36,932, would become a member of group IV. The next step in the computation is to multiply the present comparative, or per-capita, expenditures of the group of counties to which the new area would correspond in size by the population of the new area. This gives the estimated expenditure of the new area for the service in question. The difference or "saving" in table 25 is of course the difference between the actual combined expenditure of the counties in question, and their expenditure computed as above, were they combined into a single unit.

It may be pointed out that any synthetic construction of the present sort requires a fairly broad interpretation. The specific limitations are noted later in connection with the findings, although it is worthy of note at this point that there is an increasing degree of error the larger the counties included in the areas become. The tendency for comparative expenditures to "flatten out" beyond a certain population has been noticed, and unexplained county-to-county fluctuations tend more and more to confuse the changes related to size as the counties become larger.[58]

[57] This expenditure was computed by the author as a matter of interest. Differences between small and large counties show themselves to be without significance.

[58] From another point of view this merely means that, since the large counties form the base for measuring the expenditures of the consolidated areas, the analysis for those areas of which large counties are a part becomes a matter of measuring the expenditure of the area against a base which includes the constituent counties.

As might be anticipated at this stage, the computed reduction in expenditure for *general government*[59] is relatively the most important among the indicated savings through consolidation of the 22 counties into the five areas (table 25). Computed expenditure for general government for each of these areas is impressively below that of the present expenditure for this function.

The suggested union of the relatively small counties of Colusa, Glenn, and Tehama, with the somewhat larger county of Butte, to form the

TABLE 25

ESTIMATED REDUCTION IN COUNTY GOVERNMENT COST FROM CONSOLIDATION OF SMALLER COUNTIES (AVERAGE ANNUAL EXPENDITURE, 1929–30 TO 1931–32)

Classifications Concluded on Opposite Page

Name of area	General government*				Protection to persons and property†			
	Present expenditure	Computed expenditure	Saving		Present expenditure	Computed expenditure	Saving	
			Dollars	Per cent of present expenditure			Dollars	Per cent of present expenditure
North Sacramento	$354,040	$239,266	$114,774	32.4	$96,128	$67,077	$29,051	30.2
Redwood¶	276,308	219,633	56,675	20.5	71,145	61,420	9,725	13.7
Siskiyou Mountain	284,926	207,718	77,208	27.1	87,435	58,233	29,202	33.4
North Sierra	195,345	157,081	38,264	19.6	49,728	44,037	5,691	11.4
South Sierra	$233,936	$141,819	$ 92,117	39.4	$56,084	$38,779	$17,305	30.9

* Excluding "General government buildings and outlays."

† Includes only "Sheriff, constables, and jails."

¶ See pages 95 and 96 for explanation of the method of computing expenditures for this area.

north Sacramento area indicates the largest single reduction amounting to $114,774 or roughly one-third of the sum now expended by the four counties. The case of these counties is particularly interesting for they form a rather compact unit with no topographical barriers dividing different units. Combined they would not greatly exceed in area a considerable number of existing counties with equivalent populations.

The largest proportionate reduction from combination of the counties is apparent for the seven counties making up the south Sierra area. The counties which make up this area are among the smallest in the state, none having a population in excess of 10,000. Collectively, however, these counties would have a population sufficient to establish the area near the upper limit of group IV for an indicated reduction in general

[59] Excluding expenditure for "general government buildings and outlays."

government expenditure of approximately $92,000 or about 40 per cent of the amount now spent. In the case of these counties this could hardly be conceived as a net reduction from the standpoint of the community at large—the increased cost of access to the county seat for the individual is an instance in point—but in some respects this is one of the most significant of the expenditure differences here considered. The $92,000 involved is equivalent to more than $2.00 for each person resident in these counties, and has a significance in relation to all expenditures and to tax-

TABLE 25—*(Concluded)*

Estimated Reduction in County Government Cost from Consolidation of Smaller Counties (Average Annual Expenditure, 1929–30 to 1931–32)

Charities and corrections‡				Highways				Total saving	
		Saving				Saving			
Present expenditure	Computed expenditure	Dollars	Per cent of present expenditure	Present expenditure	Computed expenditure	Dollars	Per cent of present expenditure	General government, charities and corrections, protection to persons and property	General government, charities and corrections, protection to persons and property, and highways
$159,429	$152,826	$ 6,603	4.1	$831,393	$603,005	$228,388	27.5	$150,428	$378,816
178,809	165,225	13,584	7.6	568,293	535,987	32,306	5.7	79,984	112,290
169,880	132,675	37,205	21.9	540,385	523,496	16,889	3.1	143,615	160,504
109,470	100,332	9,138	8.3	403,265	395,879	7,386	1.8	53,093	60,479
$121,852	$ 99,716	$22,136	18.2	$449,060	$348,638	$100,422	22.4	$131,558	$231,980

‡ Excluding "Care of indigents, outside of almshouse, burial of indigents, and other charities," and "Outlays."

Source of data: Computations by author based on "Financial transactions."

able wealth many times that of a similar sum for the larger counties of the state.

For the two areas, north Sierra and Siskiyou Mountain, consolidating eight of the northeastern counties, there are smaller but yet significant reductions. For the four counties combined into the latter area there is an indicated reduction in general government expenditure of approximately $77,000 or more than 25 per cent of the amount now spent. Among the offsetting factors this would be, in point of area, one of the largest units in the state, and the problem of finding a county seat easily accessible from all points would not be resolved without difficulty.

The Redwood area, consolidating Humboldt, Del Norte, and Trinity, shows a reduction of approximately 20 per cent amounting to $56,675. Adding Del Norte and Trinity counties to Humboldt fails to increase

the population of this area sufficiently to bring its classification into a county group higher than that now occupied by Humboldt. For this reason the method of computation in connection with this area has been altered to measure the expenditures of the two smaller counties alone on the basis of those of the unit to which they would belong, and these have been added to the actual expenditure of Humboldt. The computed expenditure shown is hence that which would be expected for Del Norte and Trinity were they part of a unit equivalent to that which would result from their combination with Humboldt,[60] together with the actual expenditures of this county. The reduction in expenditure as shown is hence the reduction which would be indicated for Trinity and Del Norte alone were they relieved of the necessity for supporting independently the machinery of county government and were instead a part of a larger county. When it is considered that these counties are (in point of population) respectively the fourth and sixth smallest in the state, the $56,675 which is involved is indeed significant.

So close is the relation between size and comparative costs of general government at the present time (fig. 17) that the above computations are extremely thought-provoking. For the five areas and 22 constituent counties the indicated reduction in expenditure for general government is in the neighborhood of $380,000 or well over one-fourth of the present expenditure for this item. Further, it must be stressed that this amount is derived on the basis of actual expenditures of counties of corresponding size and with all of the administrative and financial shortcomings to which we know—or at least assume—this unit of government to be an heir.

The next expenditure included in the appraisal of possible economies from consolidation has been that for certain of the services rendered under the classification of *protection to persons and property*. Part of this expenditure it will be recalled—that for regulatory and inspection services and for the farm advisor and agricultural commissioner—shows some tendency to increase in comparative levels in the medium and larger counties (table 18). Since this increase is clearly related to increased levels of service in the larger counties, the expenditure has not been included in the present appraisal. However, expenditure for support of the sheriff, jails, and constables, showed an even more direct trend in comparative expenditure in the opposite direction, and it is unnecessary at this time to restate the bases for the conclusion that this diminishing per-capita level of expenditure in the larger counties is chiefly related to the size of the unit to which these services are rendered

[60] The same method of computation is employed for this area in connection with the other expenditures.

As in the case of general government, all of the suggested new areas show a substantially lower expenditure for sheriff, constables, and jail in comparison with the present expenditures of their constituent counties (table 25). Since the total sum involved is a much smaller one, the indicated decrease in absolute expenditure is of course likewise smaller. Most interesting, however, are the figures for relative or percentage decrease and especially the close correspondence from one area to another with those for general government—strongly indicative of the similarity between the operation of the size factor in determining expenditure for the sheriff and included items in the small counties, and the operation of the same factor in the case of general government.

The combined counties making up the north Sacramento area show again a reduction of about 30 per cent, amounting to slightly less than $30,000. Again considering the compactness of this area and its favorable topography and communication, it is difficult to see the offsetting factors or why as a single unit it should spend more for the services of the sheriff than a present county of roughly similar area, population, and physical character. For the Redwood area the indicated reduction with consolidation is in the neighborhood of 14 per cent and amounts to approximately $10,000. As previously mentioned, this grows entirely out of the reductions for the high-cost counties of Trinity and Del Norte. The indicated economy for the seven counties of the south Sierra area is slightly smaller in comparison with that for other areas than in the case of general government, although still in the neighborhood of 30 per cent and amounting to a total of approximately $17,000. The four counties of the Siskiyou Mountain area show the only marked difference from the general alignment of percentage reduction as between areas for general government. This area shows the greatest decrease in expenditure for the sheriff, constables, and jails, amounting to 33 per cent of the present expenditure of the constituent counties or approximately $30,000. As before, the four counties of the north Sierra area show the smallest absolute and proportionate reduction, the latter amounting to about 11 per cent.

For areas such as Siskiyou Mountain, one is inclined to hazard the possibility of not inconsiderable offsetting influences. The inaccessibility of various parts of the area, as noted in connection with general government, would increase somewhat the cost of performing certain of the sheriff's functions. However, Siskiyou County at the present time spends comparatively less for the services of this officer than other counties of similar population but much smaller size.

The indicated reduction for the portion of expenditure for protection to persons and property here included adds approximately another

$90,000 to the reduction noted for general government. While this is not a large sum, it is to be recalled that the total expenditure involved is not a large one. Divided among the four areas the $90,000 would provide a considerable volume of services to public health, or to the agriculture and economic life of the community which the majority of the individual units do not now enjoy.

For *charities and corrections* a greater county-to-county variation in per-capita expenditures exists than in the case of general government or support of the sheriff, and, as previously noted, there is somewhat less reason for relating the higher levels in the smaller counties as closely to the small size of the unit served. This has been considered especially true for relief of indigents outside of county institutions and related charitable services, and these together with "outlays" have not been included in the present appraisal.

There has been reason to believe, however, that the support of county institutions for charitable and welfare purposes does show an increasing burden of overhead for the smaller counties and these (with some of the smaller items[61]) have been subjected to appraisal in table 25. All of the areas show an indicated decrease for this item from that of the present expenditure of constituent counties, and with the exception of north Sacramento, there is again a rough parallel in proportion to the former total as between different areas. The relative reduction, however, is uniformly smaller than that for protection to persons and property and for general government.

The four counties making up the Siskiyou Mountain area show, as in the case of the preceding item, the greatest indicated reduction closely followed by the seven counties of the south Sierra area. For the remaining areas the indicated reduction is considerably smaller. The total indicated reduction for the 22 counties for charities and corrections is slightly smaller than that for the sheriff, constables, and jails, which, in turn, is a much smaller expenditure in total. In so far as the larger counties, against which the expenditure for the new areas for these services are being measured, have higher standards of service, the full change involved is of course not depicted. On the other hand, there is also the possibility of a higher level of need in the smaller mountain counties with evidence in recent times, as has been noted, of an even less stable economic fiber than the predominantly agricultural counties. While there is logical evidence of a more economical operation of the county welfare institutions in a unit larger than most of those being here con-

[61] Certain of these show but little trend from small county to large, as in the case of the counties' contribution to the care and examination of its feeble minded and insane. They are a minor part of the total, however, and have been carried in the present analysis merely for purposes of convenience.

sidered, it must be remembered that the basis for appraisal is less certain than in the case of the two items previously considered. As a practical issue it should also be remembered that the institutional services of these smaller counties are now "going concerns." Their consolidation into larger, and more economical units, for service of a larger area would not be accomplished without some fresh expenditure.

Expenditures for *highways*, it has been noted, are included in but tentative fashion. The indicated reduction for this item is approximately equal to that for general government although it arises as a smaller percentage of a larger total figure. The counties which are consolidated in the areas here being considered are in the main mountainous in character and sparsely populated. For this as well as other reasons (page 47) it seems certain that a part of the comparatively higher levels of highway expenditure might be necessary in comparison with more populous and less rugged counties. Another and important aspect of the situation, however, arises from the high cost of maintaining road machinery and equipment, and for providing supervision in the even smaller supervisorial road districts (page 48). That this is an item of some significance is shown by the indicated saving in road expenditure among the various areas. The most significant reduction among the various areas is that for north Sacramento which, however, combines 2 of the smaller valley counties with 2 others which have substantial areas of valley land. Moreover, the two valley counties, Glenn and Colusa, have higher comparative highway expenditures than the more populous counties of Tehama and Butte with their larger area and mountainous territory. Further evidence that the size of the road-building unit has an important influence on comparative expenditure rests in the observation that the second most significant of the indicated reductions comes from the suggested combination of the 7 small mountain and foothill counties to form the south Sierra area. This is in contrast with the smaller reduction from combining the (in general) much more populous counties of Siskiyou, Modoc, Lassen, and Shasta.

Just what part of the indicated reduction of 27 per cent in highway expenditure for north Sacramento, or 22 per cent for south Sierra, or of the smaller and less significant amounts for other areas is to be related to the size of the unit rather than to the difficulties of road-building, must remain, however, an unknown. The author hazards the opinion that a considerable and perhaps even a major proportion of the approximate $385,000, indicated as a reduction, might be actually effected. This would probably be realized in the form of an increased return for expenditure through the more economical operation of a more efficient road-building and maintenance unit.

For the average of the three years 1929–30 to 1931–32, the 22 counties for which the possible expenditure reduction has been appraised, spent for all services and functions slightly over $15,000,000. On the basis of existing county organization and the actual expenditure of the counties of equivalent size, the reduction for those expenditures which have just been considered and which appear more or less definitely related to the number of people served, would fall somewhere between $500,000 and $1,000,000 in total, perhaps approaching the latter figure more closely. On the surface this does not appear to be a large sum, but such a view is inadequate. Four of the counties[62] which are included in this appraisal spend 6.6 million dollars of the total or not far short of half of that for the 22 counties. Since these 4 counties approach in size those which are being used as the base for purposes of measuring the expenditures of the new areas, their expenditures are reduced in rather small degree. For the remaining counties spending 9.5 million, the reduction in expenditure from consolidation bears a sizeable relation to the total. The sum of $150,000 might be arbitrarily settled upon as the economy from consolidating road districts in the five areas. When this is combined with the savings in general government, protection to persons and property, and charities and corrections for the five areas, the total of approximately $700,000 so obtained exceeds the present total (individual) expenditure of 16 counties of the state. Furthermore, just as there is but little change for the larger counties which are in close proximity with the base against which measurements are being made, so there is the maximum reduction for the very small high-cost counties. For these counties consolidation holds forth the promise of definite economy.

In appraising the advantages of county consolidation, certain offsetting disadvantages must also be taken into account. Measurement of the economies in operating the county governments and service agencies themselves does not give a complete balance sheet for judging whether such a consolidation would be to the advantage of the residents of the counties concerned. With larger counties people must travel greater distances in order to transact business which requires a visit to the county seat. Extra expense and time thus used are very difficult to measure but constitute an offsetting debit, though probably not a large one, against the advantages here shown. Such consolidations also involve some scrapping of present facilities and a certain amount of new construction. Even though these counterbalancing factors could be measured, it is not likely that they would in most cases alter the conclusions which have been stated.

[62] Humboldt, Butte, Siskiyou, and Placer.

CONSOLIDATION OF COUNTIES WITH LARGER POPULATIONS

The evidence from the present study is not clear as to the economy from consolidating the medium and larger counties of the state—roughly those counties with a population in excess of 40,000. The overhead expenditures for statutory and traditional offices and functions, supported at high cost by the small county, become of much less importance in these larger units. The tendency of many of these expenditures to "flatten out" after a certain county size has been reached or, otherwise expressed, to increase proportionately with the increase in population, has also been noticed. The economy of county consolidation is from sharing a single overhead by a larger number of people. If this overhead, as indicated, becomes of minor importance for the larger counties and in any case ceases to be an overhead by increasing with the increase in population, then the gains from county consolidation disappear.

If it cannot be shown that a county with a population of 100,000 is serving its population with a greater efficiency than a county of 40,000, then there is little to indicate the desirability of consolidating counties of the latter population. Even taking into consideration the possible higher standards of service in the very large counties and the fact that a small percentage reduction in expenditures would amount to a considerable figure with the large total expenditures involved, the present study does not bear strong evidence that the county of what may be termed a "reasonable" population is much less efficient than a county of large population. This being the case it would appear that first emphasis, at least in matters pertaining to county consolidation, should be directed towards those county units which have an "unreasonably" small population.

ACKNOWLEDGMENTS

The author is especially indebted to Professor M. R. Benedict of the Giannini Foundation, with whose aid the study was first organized, and who has been in constant touch with its progress.

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APPENDIX A

SOURCE AND CHARACTER OF EXPENDITURE DATA

Obviously, a major consideration in a study of the present character is that of available data and their authenticity and general useability. Data on county expenditures are available from two possible sources: (1) reports of the individual counties and (2) compilations made by the State Controller's Office and published annually under the title of "Financial Transactions of Municipalities and Counties of California."[63]

Main reliance has been placed on this second source for the basic material of the study. The advantage of working with data in a semicompiled condition in a study of this sort is obvious, and a detailed compilation from budgets or financial statements of individual counties was quite beyond the resources, either of time or money, available for the present work. Moreover, while as noted later the data used had some fairly serious shortcomings, it seems certain that the extra advantages accruing to more logical segregations of expenditure would not have justified the extensive duplication of effort involved. Use of this material has enabled the study to be carried on from approximately the point where the compilations of the State Controller's Office leave off.

It is of importance, however, that a number of items in connection with the State Controller's data be noted rather carefully in their bearing upon the present study. Among these it may be mentioned that the segregation of capital and current expenditure as made in this report appears to be on a rather doubtful basis. A capital expenditure or "outlay" is regarded as such when the expenditure is for something considered to be of a permanent character. Obviously, the line of demarcation between the permanent, semipermanent, and transitory is hazy and not likely to be interpreted alike by any two county officials.

For the purposes of the present study an effort has been made to recombine current and capital expenditure wherever possible. In connection with the analysis of comparative increases in expenditure for various functions (pages 7 to 30), the influence of heavy capital outlays for one or a few counties in any one year is largely overcome by the fact

[63] California, Office of Controller. Annual report of financial transactions of municipalities and counties of California, annual issues. California State Printing Office, Sacramento. Cited throughout as "Financial transactions."

This report was first required by an act of the Legislature of April 21, 1911, which directed the State Controller to "compile and publish annually reports of the financial transactions of each county and municipal corporation." Several years elapsed before complete reports were issued, in fact, such completeness awaited a substantial increase in the penalties provided for local officers who failed to file requisite data with the State Controller.

that data for so many counties are included. There is still, however, some possibility of distortion for any one year in connection with certain types of expenditure. The same also holds true for the influence of expenditures which although recurrent, vary in weight from year to year. In the case of major groups of expenditures such as those for education and highways, or those grouped under the heading of "charities and corrections," the possibility of distortion from the above factors, even for one year, is not large. In the case of general government or smaller expenditure items such as health and recreation, the possibility is considerably increased. Heavy increases in expenditure for general government are noted for the year 1926–27. A closer examination, however, shows that this is the result of the inauguration of courthouse construction in San Bernardino County and Santa Barbara County. A considerable drop in expenditure for general government in 1929–30 may be related to the completion of the Santa Barbara structure and more particularly to the low election expenditure in that year. The increase in the following year is largely a result of the elections in the fall of 1930 and also some increase in building expenditure.

While obviously, longer time trends in expenditure are unaffected by the above variations, shorter time inferences must be made with care. Since present analysis is concerned with the more general of the movements, irregularities from the above-cited causes are not of particular concern. They should be kept in mind, however, in extending the employment of data presented beyond the limits of use in this study.

In connection with the cross-sectional examination of expenditures (pages 30 to 86) on the basis of a three-year average, the combination of capital and current expenditures offers no serious difficulty. In the case of many groups of expenditures the so-called "outlays" make up but a minor part of the total. Simply combining the current and capital disbursements in such cases gives a picture of expenditures which is virtually as valid as were there an accurate separation. In the opposite extreme are certain groups of expenditures, such as that for highways and bridges, where the capital items comprise a large part of all disbursements. In such instances it is likewise proper that capital and current items be taken together, since expenditures for permanent structures are almost as normal to any year's highway operations as expenditures for grading or for other work that is repeated each year. As satisfactory a picture of the level of highway expenditure is obtained in the two combined as in a separation, even were the latter on a satisfactory basis. The most important problem in this connection comes in items such as education and particularly, general government, where a building program, for example, might distort possible comparisons in expenditure levels,

even for groups of counties. It is believed that this difficulty has been satisfactorily resolved by use of the three-year average of county expenditures. Some school-building, like some road-building, is a normal expenditure, and a close examination of the data shows that any apparently abnormal expenditure does not sufficiently influence the various measures of expenditure of county groups on the basis of a three-year average to invalidate or even seriously distort the basis for inference. In the case of general government, instances have been indicated where courthouse and similar construction influence the data used.

In some respects more troublesome than the year-to-year fluctuations in the data as a result of capital outlays and periodical expenditures, are errors in reporting expenditure. County accounting methods are far from precise, and in some instances, those in charge have not shown a particularly keen appreciation of their responsibility for furnishing accurate and complete reports to the State Controller's Office. Every effort has been made to detect and rectify discrepancies, but considering the volume of the data handled it would be indeed optimistic to expect that all or perhaps even a considerable portion of these had been eliminated. Here again, however, the broader trends remain almost completely unaffected and it is the finer judgments that are to be avoided.

By far the knottiest problems in connection with data employed are those arising out of district expenditures. In organizing a study such as the present, several lines of approach might be taken with reference to these expenditures. Districts might be considered to constitute a unit of government quite apart from the county and their expenditures excluded as being outside the universe of study. The difficulty with this view, however, is that the services of counties and of districts are in many cases similar as well as supplementary, and as such there may be partial substitution of one for the other under certain circumstances. An example of this may be seen in the case of aggressive street or road-building by a number of road-improvement districts in a county. In this case the county-highway expenditure may perhaps be lower than if there were little district activity. In any case, data on county-highway expenditures will not give a satisfactory picture of the total of such expenditures for the county. Further, while it has been the policy of the present study to look at expenditures objectively without detailed consideration of their burden, it may be remembered that county and district both rely in large part on the same tax base. Looking at the expenditure of the county for a particular service through the eyes of the taxpayer concerned is a meaningless process if a district, of which his property forms a part, is also performing a portion of that service or one similar to it.

The ideal method would be to handle district and county expenditures separately and also combined as a total figure for local expenditures for a particular service. The nature of the data used has made it necessary to rely on the second method alone in the present study. Classified data for district tax levies, which are much more complete than similar data for expenditures, indicate that in 1930–31 total special and district tax levies handled through the county treasury amounted to slightly in excess of $100,000,000. The largest part of this, or about $78,000,000 was collected for elementary and high schools, and as an expenditure it comes under the various educational services, according to the practice of the State Controller's Office.[64] Likewise, expenditure of road districts has been included under highway expenditures. District expenditures devoted to service of bonded indebtedness for school purposes and road districts are included under the heading of payment of interest and redemption of debts. This latter item also includes interest payments for certain service districts, expenditures of which are not included in the study. While these are a relatively insignificant part of the total, there is an admitted inconsistency in their inclusion. There is no possible basis, however, for segregating them from interest on school and road district indebtedness.

Operating expenditures of reclamation, levee, and other districts are not included in the present study. It is possible that expenditures of fire, lighting, mosquito abatement, and similar service districts might properly have been included, but no basis was available for separation from such of the reclamation, levee, and like districts as are administered by the county. These latter constitute a type of public enterprise distinctly apart from that with which the present study is concerned.[65]

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[64] Computations based on "Financial transactions," 1931. The extent of expenditures for service on indebtedness of such districts is noted on page 82.

The author is indebted to Miss Ruby Sawyer, Statistician, Office of the Controller, for assistance in clarifying the distribution of district expenditures as made in "Financial transactions." This report could be improved by a clear-cut segregation of county and district expenditures or even by more specific statement of the methods now employed in allocating district expenditures to various classes of expenditure. From the standpoint of the present study this was the most unsatisfactory feature of the report as a basic source of data.

[65] Expenditures of these types of districts coming under county administration and included in the State Controller's reports are relatively small.

APPENDIX B

COUNTY EXPENDITURES INCLUDED IN THE ANALYSIS

In compiling the total or gross expenditures for use under "Historical Analysis of County Expenditure," only those expenditures have been included which are clearly for account of county service rendered or for the organization which makes possible the rendering of such services and the continuance of its functions. These include expenditures for the following:

Education
Highways and bridges
Charities and corrections
General government
Protection to persons and property
Conservation of health and promotion of cleanliness
Recreation
Miscellaneous
Interest on indebtedness

As noted in Appendix A district expenditures for education and highways have been included with county expenditures for these items, while expenditures on the account of reclamation, irrigation, and levee districts have been excluded. Expenditures for the redemption of debt, both on county and district bonds, have likewise been excluded from these compilations. Over a period of years the inclusion as expenditure of both the funds from a bond issue and the funds used to pay off the issue involves a double counting. From the standpoint of the taxpayer the expenditure of greatest significance is probably that which is devoted to paying off the debt. However, a more logical conception of expenditure is that which looks upon it as being consummated at the time when the equivalent is received. Although expenditure of the United States government in recent times for redemption of Panama Canal bonds might be considered indirectly as the expenditure for the Canal, the everyday view would be that the expenditure was made when the Canal was built.

Interest on bonded indebtedness, on the other hand, has been included as an expenditure, although, from the standpoint of rigid economic theory, the justice of so doing might be questioned. Argument against including interest would be based on the doctrine that such payment is merely equivalent to the difference between the desirability and convenience of future as against present expenditure. Inverting the familiar

justification of interest,[66] it is simply the price which the supporters of a unit of government are willing to pay for the immediate gratification of a want with payment postponed, or spread over the life of the object of the expenditure. In this sense interest on indebtedness, instead of being considered an expenditure, is merely the equivalent of the difference in convenience and desirability of two means of providing that which is to be expended.

A more realistic view of expenditure, however, is likely to place a different interpretation on payment of interest. It is difficult indeed to exclude from the view the annual levy against the county treasury for sustaining the overhead burden of indebtedness. There is also an assumption implicit in the foregoing reasoning that the choice between current financing and borrowing is a rational one motivated by the desire for maximum utility from the apportionment of social resources through time. It is doubtful indeed if the practical issue of taxation versus borrowing by a county is often decided on the basis of such a criterion. In such case more is to be gained by simply regarding interest expenditure as a payment of parallel category to others made by the county—or as a remuneration for the "service" performed by those who enable postponement of immediate payment. Furthermore, as Bastable[67] has pointed out, there is danger of looking upon all expenditures—other than that of a recurrent nature—as extraordinary, the latter in turn to serve as a justification for borrowing. Actually nonrecurrent expenditure may be just as "ordinary" as recurrent expenditure, though the specific form of any given expenditure be not duplicated once in several decades. As far as California counties (and districts) have employed this method of financing—an issue which cannot be resolved at this time—interest payments must be regarded merely as the penalty for a very human lack of foresight in financial administration or the product of political expediency. In such case there is little justification for removing them from the sphere of county expenditure in the light of the objectives of the present study.

The combined City and County of San Francisco has not been considered as a county in this study. This is in conformity with the practice of the Controller, and the character of the unit in question makes it far

[66] For example see: Marshall, Alfred. Principles of economics. 8th ed. p. 580–595. The Macmillan Co., London. 1930.

[67] Bastable, C. F. Public finance. 3d ed. p. 669. The Macmillan Co., New York. 1927. In this connection Professor Bastable makes the following statement: "The expenses of the State do, no doubt, vary from year to year, and any sudden increase which has to be met by taxation may prove inconvenient, but on the other hand we have to remember that so-called extraordinary expenditure is itself recurring. To treat all fresh claims as extraordinary and to meet them from loans is an easy, but dangerous course."

from typical of the California county in general. The counties of Los Angeles, Alameda, and San Diego,[68] referred to herein as the "Metropolitan Counties," have been separated from the remaining counties of the state wherever total county expenditure figures have been used in the analysis. These counties are predominantly urban and their expenditures have been a less immediate concern of the present study. An equally important consideration, however, has been that the expenditures of these three counties, with well over two-thirds of the population of the state (excluding the City and County of San Francisco), tend to overshadow the expenditures of the smaller counties.[69] A much better appreciation of levels and trends in total expenditure of the 54 smaller counties is to be obtained by separating them from the expenditure of the three larger ones. In some instances a total figure covering expenditures of all counties has been included largely as a matter of interest and for purposes of comparison.

For purposes of the cross-sectional analysis of comparative, or per-capita, levels of expenditures in different groups of counties, as carried out in "The Present Situation in County Expenditure," expenditure for redemption of indebtedness has been reincluded. In the search for a clearly defined picture of county expenditures at a given time, it is entirely logical to look at both new capital expenditures (rapidly declining in two of the three years considered) and expenditures for redemption of past indebtedness.

This implies an objective view of county expenditure as gross funds disbursed by the county treasury without regard for their source. However, since county funds for the expenditures here considered are gathered from a variety of sources, the minute sacrifice of the element of "burden" that results from this approach is not serious.

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[68] The ratio of rural farm to urban population in 1930 as shown by the Census is as follows: Los Angeles, 1:67; Alameda, 1:46; and San Diego, 1:17.

[69] This is well brought out in fig. 1. By taking the fiscal year 1930–31 as an example, expenditures of these 3 counties stood at $145,614,901 or 1.23 times the expenditures of all other counties combined. It may be of interest to note that the expenditures of Los Angeles County, including debt redemption, during this year were approximately four times greater than the total expenditure of the federal government in 1840 and twice as great as federal expenditures at the beginning of the Civil War. (Data from: Annual Report of the Secretary of the Treasury. 1924.)

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FORCING GLADIOLUS OUTDOORS BY HEATING THE SOIL WITH ELECTRICITY

JAMES R. TAVERNETTI AND S. L. EMSWELLER

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UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

FORCING GLADIOLUS OUTDOORS BY HEATING THE SOIL WITH ELECTRICITY[1, 2]

JAMES R. TAVERNETTI[3] AND S. L. EMSWELLER[4]

THE GROWING OF GLADIOLUS OUTDOORS for cut flowers is an important part of the floral industry in the United States. According to the Census of 1930, this crop then comprised slightly over 26 per cent of the land area used and over 29 per cent of the value of all cut flowers grown in the open. This popularity results from the wide adaptability of the gladiolus to different types of climatic and soil conditions and from its use both as a cut flower and as a decorative plant. The wide range of color and type, the ease of growing, and the long season of bloom are also contributing factors.

Although the early cut flowers bring a higher price, little or no attempt has been made to produce them outdoors. The common practice is to plant the corms as soon as possible for the earliest crop and to make successive plantings every few weeks. The time required to produce the flowers varies with the climate. It is often unduly prolonged by low soil temperatures that cause early planted corms to lie dormant for a long period.

Because of its convenient adaptability and relatively low initial cost, heating the soil by electricity has recently stimulated interest in the forcing of gladiolus outdoors. In order to determine the effect and costs of this method of forcing outdoors, a series of experiments was conducted at Davis during the winter and spring seasons of 1931, 1932, and 1933. The first year, plants were grown in an uncovered frame; the second, in the open field; and the third, in a covered frame.

In all the experiments the corms used were between 1½ and 2 inches in diameter. They were dug about October and were held in storage

[1] Received for publication July 6, 1934.

[2] This publication is the twelfth of a series reporting results of investigations conducted by the California Agricultural Experiment Station in coöperation with the California Committee on the Relation of Electricity to Agriculture.

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until planted in a basement where the temperature varied between 5
and 59° Fahrenheit. Each year all corms were dipped in Semesan
soon as they had dried out after harvest, and again a few days befo
planting. Only sound, healthy ones were used.

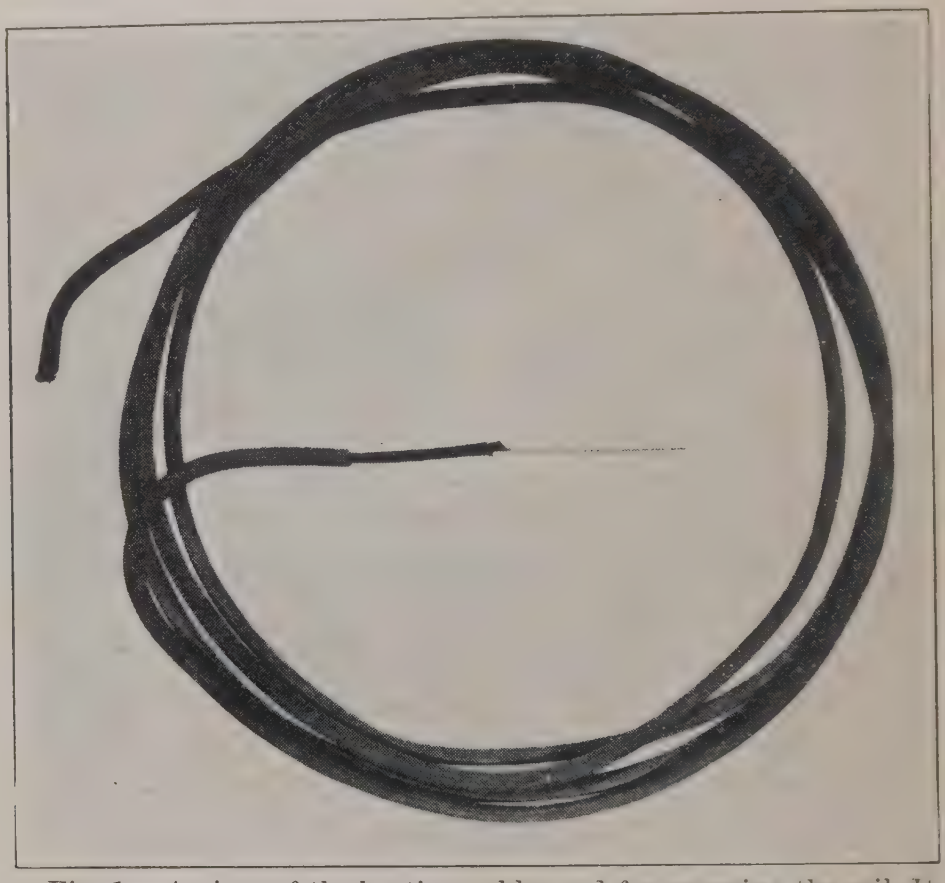


Fig. 1.—A piece of the heating cable used for warming the soil. It consists of an insulated resistance wire enclosed in a lead sheath. A 60-foot length connected to a 110-volt circuit will heat about 4 square yards of soil. This cable costs about five cents per foot.

The soil was warmed by a special heating cable (fig. 1), consisting
a resistance wire insulated with felted asbestos and enclosed in a l
sheath about ¼ inch in diameter. This cable had a resistance of ½ o
per foot and was connected to a 110-volt circuit.

FORCING IN UNCOVERED FRAMES

In 1931 the corms were grown in an uncovered frame 6 × 15 feet, l
of which was heated and half unheated (fig. 2). A space of 1 foot
left between the two plots. The heat was furnished by 45 feet of s
heating cable, which was looped back and forth, as shown in figur
and buried 5 inches deep in trenches 12 inches apart. The total c
nected load was about 500 watts for the bed or about 12 watts per squ
foot.

Fifty-four corms of the Prince of Wales and 36 of the Shaylor varieties were planted in each bed on December 15, 1930. There was 1 foot between the rows, which were midway between the legs of the cable loops; and the corms were spaced 4 inches apart at a depth of 3 inches.

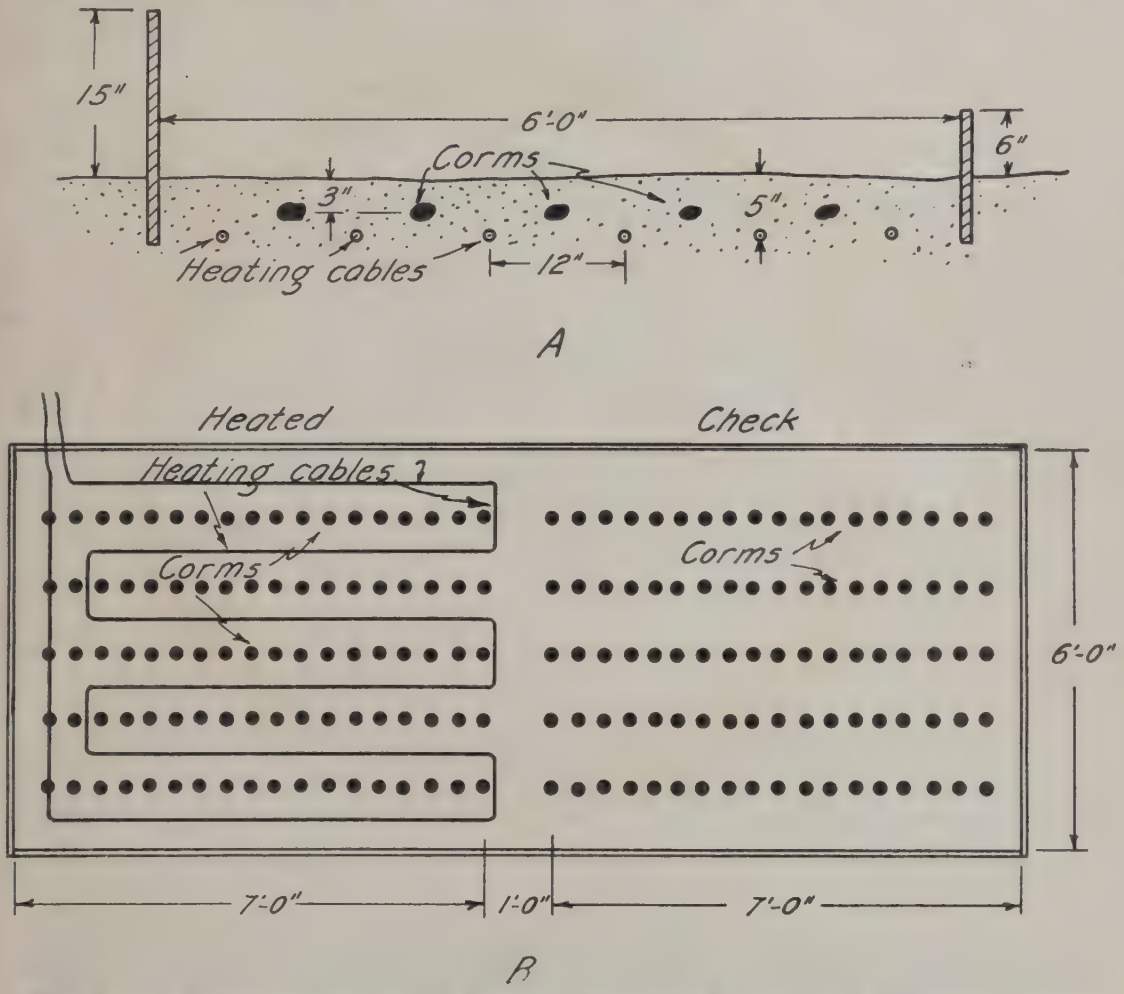


Fig. 2.—*A*, Cross section, and *B*, plan of heated and check beds in the uncovered frame.

The heat was first applied on January 14, 1931, and was left on until April 20 (96 days). During this time it was automatically controlled through a thermostat by the temperature in the top 10 inches of soil at a point midway between two legs of a cable loop. The ranges of temperature for both soil and air were recorded during the period of heating. They are given in table 1 along with the electrical energy consumed. During the heating period, the average range of soil temperature (73° to 80° F) in the heated bed was about 16° higher than in the check bed (58° to 63° F). This difference varied from about 20° during the first few weeks to about 5° during the last weeks. The energy consumption averaged 1.19 kilowatt-hours per square yard per day or a total of 114 kilowatt-hours per square yard for the entire heating period.

TABLE 1

ENERGY CONSUMPTION AND RANGE OF SOIL AND AIR TEMPERATURES FOR EXPERIMENTS IN UNCOVERED FRAME, 1931

Period	Energy consumption, kw.-hrs. per square yard per day	Soil temperatures* in heated bed, deg. Fahr.		Soil temperatures* in unheated bed, deg. Fahr.		Air temperatures around beds, deg. Fahr.	
		Av. min.	Av. max.	Av. min.	Av. max.	Av. min.	Av. max.
January 14 to 25	1.78	....	....	47	50	36	57
January 26 to February 1	1.50	70	76	51	55	40	59
February 2 to 8	1.47	73	75	54	58	44	64
February 9 to 15	0.89	74	76	56	60	44	63
February 16 to 22	0.28	66	73	54	60	40	62
February 23 to March 1	1.65	72	79	55	60	38	65
March 2 to 8	1.16	74	83	58	65	38	72
March 9 to 15	1.38	73	82	58	63	42	67
March 16 to 22	0.98	73	82	62	66	45	72
March 23 to 29	1.26	75	83	61	66	39	67
March 30 to April 6	1.04	74	86	64	69	40	77
April 7 to 13	1.01	75	86	67	72	44	79
April 14 to 20	0.64	73	83	70	80	45	84
Average	1.19	73	80	58	63	41	68

* The soil temperatures are the average in the top 11 inches of soil.

The growth in the heated bed was always considerably more advanced than that in the check bed (fig. 3). At first the foliage was a light green but as the season advanced it became normal; and the quality of flower produced was in no way inferior. In the heated bed, both varieties be



Fig. 3.—The upper picture was taken on February 8; the lower on April 28, 1931. The heated plot was consistently earlier in growth and flowering.

gan to bloom[5] about two weeks earlier than in the unheated (fig. 4) and had finished before 25 per cent of the latter had bloomed. All the Prince of Wales variety were harvested 25 days before the last spike was cut

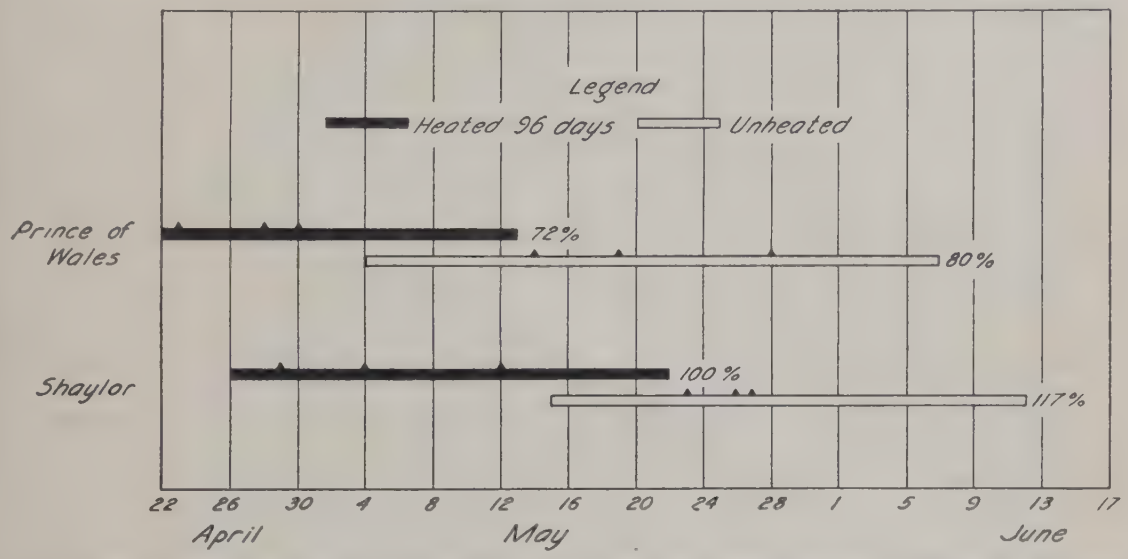


Fig. 4.—Blooming period of gladiolus in the uncovered frame. Points on the bars indicate dates when 25, 50, and 75 per cent, respectively, of the spikes were harvested. The figures at the ends of the bars show percentages of spikes harvested in relation to the number of corms planted.

on the check plot, while the Shaylor variety showed a difference of 21 days in favor of the heated. The percentage of corms blooming is slightly in favor of the check plots, but it may not be significant, since the number involved is small.

FORCING IN THE OPEN FIELD

In 1932, eight beds in the open field, each 18 inches wide and 26 feet long, were used, four being heated and four unheated (fig. 5). In each heated bed a single circuit of 52 feet of soil-heating cable was buried to

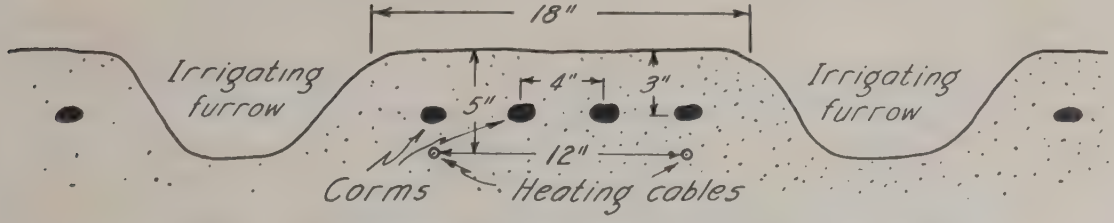


Fig. 5.—Cross section of the heated bed in the open field.

a depth of about 5 inches. It was placed in a hairpin loop running the length of the bed with the legs spaced about 12 inches apart. The connected load in each bed was about 475 watts, or about 12 watts per square foot.

[5] Spikes were considered mature when the first flower opened.

TABLE 2

ENERGY CONSUMPTION AND RANGE OF SOIL AND AIR TEMPERATURES IN THE OPEN-FIELD BED, 1932

Period	Energy consumption in bed heated 60 days, kw.-hrs. per square yard per day	Soil temperatures* in bed heated 60 days, deg. Fahr.		Energy consumption in bed heated 102 days, kw.-hrs per square yard per day	Soil temperatures* in bed heated 102 days, deg. Fahr.		Soil temperatures* in unheated bed, deg. Fahr.		Air temperatures around beds, deg. Fahr.	
		Av. min.	Av. max.		Av. min.	Av. max.	Av. min.	Av. max.	Av. min.	Av. max.
January 26 to 30	2.61	58	65	2.62	57	64	42	52	39	54
January 30 to February 6	2.61	57	64	2.62	56	63	41	49	36	48
February 6 to 13	2.34	57	66	2.36	56	69	42	58	35	58
February 13 to 20	2.41	57	68	2.42	64	69	40	54	32	59
February 20 to 27	1.75	64	74	1.73	60	76	47	66	40	70
February 27 to March 5	1.65	64	74	1.61	60	75	47	64	38	68
March 5 to 12	1.35	68	74	1.36	66	73	52	66	47	69
March 12 to 19	1.45	66	72	1.37	66	74	55	67	48	69
March 19 to 26	1.55	64	77	1.45	64	76	51	68	44	71
March 26 to April 2	.....	....	....	0.91	67	83	56	77	45	72
April 2 to 9	.....	....	....	1.19	68	80	53	76	38	74
April 9 to 16	.....	....	....	1.12	68	81	59	78	43	74
April 16 to 23	.....	....	....	0.96	66	82	56	80	39	68
April 23 to 30	.....	....	....	1.33	66	77	55	69	46	69
April 30 to May 7	.....	....	....	0.73	69	80	60	77	46	77

* Soil temperatures were taken at the same depth, 3 inches, as the corms.

Six varieties of gladiolus—Rose of 1910, Jack London, Shaylor, Scarlano, Prince of Wales, and Bothkin—were planted on November 11, 1931. The rows were run across the beds, spaced 8 inches apart; and four corms were planted about 3 inches deep and 4 inches apart in each row.

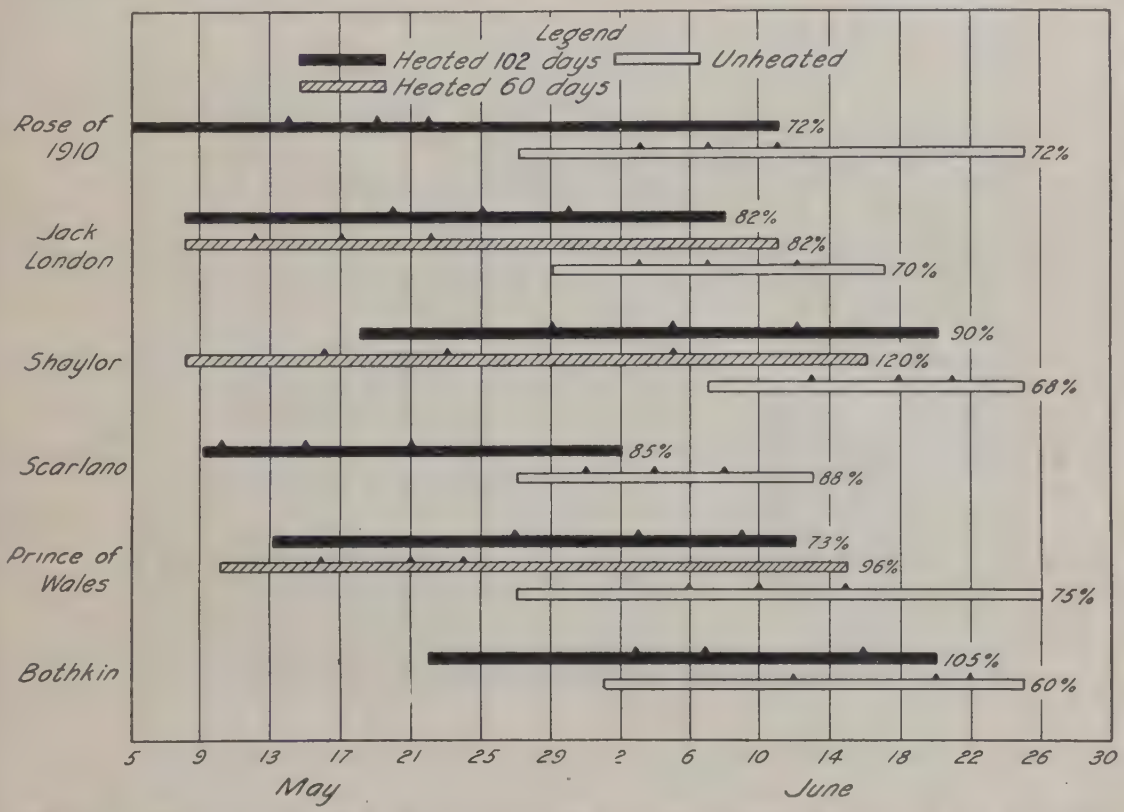


Fig. 6.—Blooming period of gladiolus in open-field beds. Points on the bars indicate dates when 25, 50, and 75 per cent, respectively, of the spikes were harvested. The figures at the ends of the bars show percentages of spikes harvested in relation to the number of corms planted.

The current was first turned on in all four heated beds on January 26, 1932. In three it was left on until May 7 (102 days), and in the fourth until March 26 (60 days). The heat was automatically regulated by a thermostat that was controlled by the soil temperature at a point midway between the legs of the cable and at the same depth as the corms. The thermostat was set to turn the electric current on at 60° and off at 66° F.

Table 2 gives the electrical energy consumed and the temperature range for the various beds during the periods of heating. It shows a very close agreement of the soil temperatures and energy consumption in the heated beds during the first 60 days. The minimum soil temperature during this period averaged 16° warmer than in the unheated bed, whereas during the succeeding 38-day period it averaged 11° warmer. Although soil-temperature readings were not taken after the heat was discontinued in the 60-day bed, in all probability they were the same

as those in the unheated bed for the same period. The energy consumed in the bed heated 102 days dropped from an average of 1.95 kilowatt hours during the first 60 days to 1.04 during the last 38 days of heating

The blooming periods are shown graphically in figure 6. Of the six varieties planted, three—Jack London, Shaylor, and Prince of Wales—

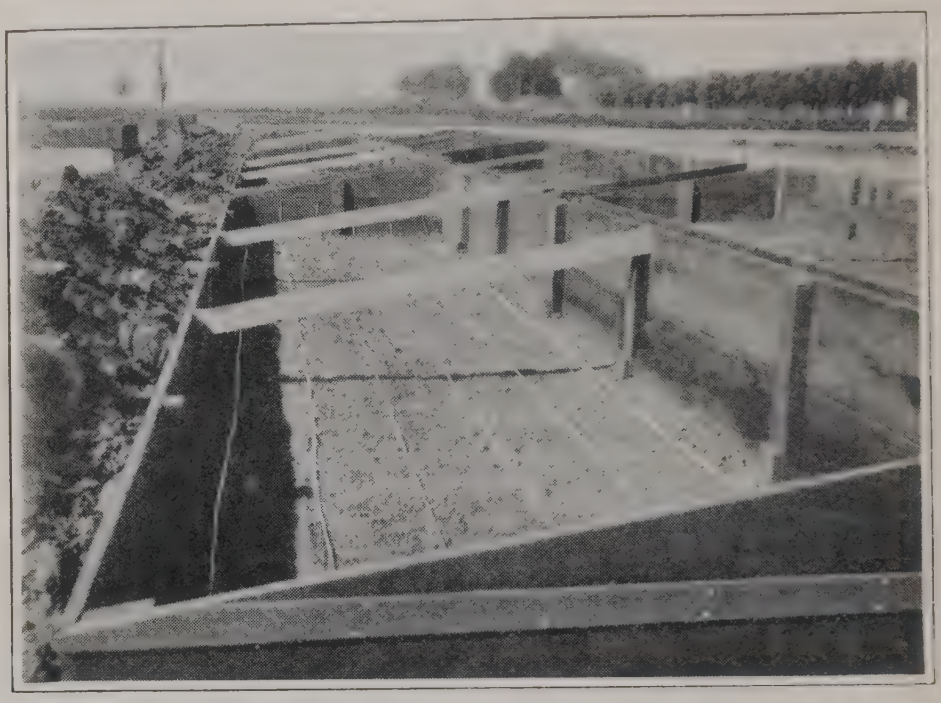


Fig. 7.—View of a heated bed in a covered frame, showing the heating cable in place ready to be covered with 3 inches of soil. After the bulbs were planted, 3 more inches of soil was placed over them.

were exposed to both the 60 and 102-day periods of heating. In eac instance those receiving the shorter period of heat began blooming b fore or as soon as those receiving the maximum amount, 75 per cent Prince of Wales and over 50 per cent of Jack London and Shaylor bein harvested before one-fourth of the 102-day plots had bloomed. In a varieties the unheated corms began to bloom from 10 to 22 days lat than the heated.

The percentage of blooms shows a rather marked difference in son varieties. This was partly caused by a prolonged period of high te peratures about the middle of June, when the young buds were so bad scorched that they never recovered sufficiently to produce a norm spike.

FORCING IN COVERED FRAMES

In 1933 the plantings were made in four 6 × 30-foot outdoor fram three of which were heated and one unheated. During the first ni weeks of the heating period, all the frames were covered at night and cloudy days by sash made of wax-impregnated muslin. In each of t

TABLE 3

ENERGY CONSUMPTION AND RANGE OF SOIL AND AIR TEMPERATURES IN COVERED FRAMES, 1933

Period	Soil temperatures* in frame heated 35 days, deg. Fahr.		Energy consumption, kw.-hrs. per square yard per day	Soil temperatures* in frame heated 63 days, deg. Fahr.		Energy consumption, kw.-hrs. per square yard per day	Soil temperatures* in frame heated 98 days, deg. Fahr.		Energy consumption, kw.-hrs. per square yard per day	Soil temperatures* in unheated frame, deg. Fahr.		Air temperatures* surrounding frames, deg. Fahr.	
	Av. min.	Av. max.		Av. min.	Av. max.		Av. min.	Av. max.		Av. min.	Av. max.	Av. min.	Av. max.
November 29 to December 5	63	67	1.53	63	70	1.62	60	66	1.33	44	48	36	61
December 5 to 12	62	67	1.21	64	71	1.44	58	65	1.26	41	47	26	60
December 12 to 19	62	68	1.12	63	69	1.35	59	66	1.16	38	46	20	46
December 19 to 26	63	65	1.04	62	69	1.22	63	67	1.04	44	48	31	50
December 26 to January 2	63	67	1.01	65	71	1.25	63	69	0.99	43	50	29	51
January 2 to 9	....	....	.....	68	72	1.39	63	67	1.04	43	47	31	51
January 9 to 13	....	....	.....	68	72	1.19	63	68	0.94	41	49	30	54
January 16 to 23	....	....	.....	67	69	1.31	64	67	1.04	44	49	29	48
January 23 to 30†	....	....	.....	56	58	0.85	62	66	0.99	44	48	33	48
January 30 to February 6	....	....	.....	....	....	.....	50	58	0.00‡	44	53	34	54
February 6 to 13	....	....	.....	....	....	.....	54	58	1.55	39	50	31	58
February 13 to 20	....	....	.....	....	....	.....	51	62	0.83	42	52	33	55
February 20 to 27	....	....	.....	....	....	.....	57	71	0.99	43	59	33	62
February 27 to March 6	....	....	.....	....	....	.....	59	73	0.84	48	63	36	65

* Soil temperatures taken at a depth of 4 inches, midway between two heating cables.

† Covers were removed from all beds on January 30.

‡ Switch accidentally left open during this week.

heated frames (fig. 7) were three 60-foot lengths of soil-heating cabl buried to a depth of 6 inches. Each was arranged in a hairpin loop run ning the length of the frame with the legs spaced 12 inches apart. Ther was a total connected load of about 1,200 watts per frame or 6⅔ watt per square foot.

The corms of five varieties of gladiolus—Los Angeles, Jack London

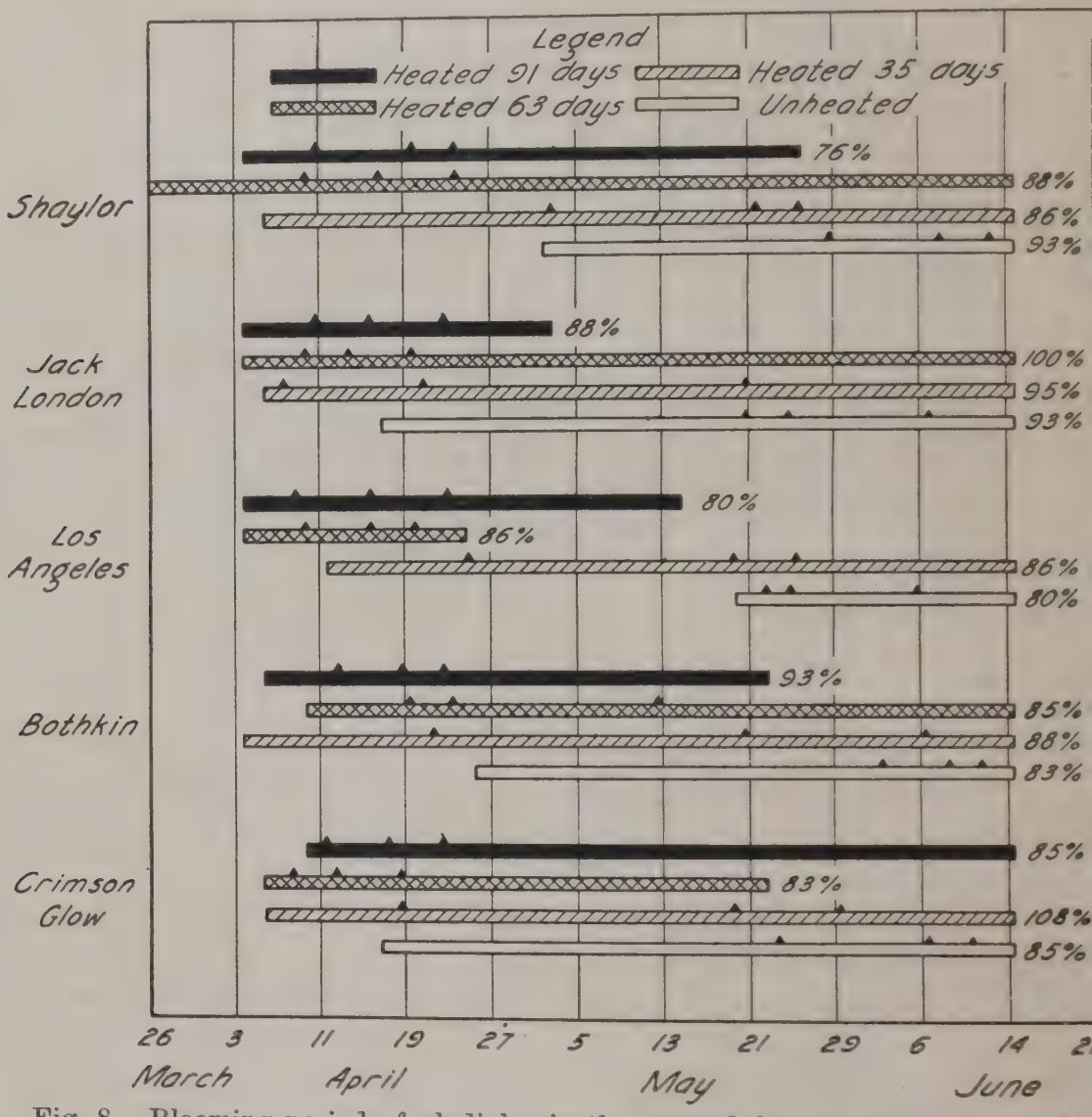


Fig. 8.—Blooming period of gladiolus in the covered frames. Points on the ba indicate dates when 25, 50, and 75 per cent, respectively, of the spikes were ha vested. The figures at the ends of the bars show percentages of spikes harvested relation to the number of corms planted.

Bothkin, Crimson Glow, and Shaylor—were planted in each bed on O tober 19, 1932. They were set at a depth of 3 inches and spaced 5 inch apart each way.

The heat was first applied in all the heated beds on November 29. was left on in one until January 2 (35 days), in another until Januar 30 (63 days), and in the third until March 6 (98 days). In the thir

bed, however, the main switch was accidentally left open during the week of January 30 to February 6, so that it was heated only 91 days. The temperature in each bed was automatically controlled through individual thermostats buried at the same depth and midway between two of the cables. The thermostats were set to turn on the electricity at 62° and off at 68° F.

The energy consumption and range of temperatures in the various beds during the heating periods are shown in table 3. From November 29 to January 30 the soil temperatures averaged about 20° warmer in the heated than in the unheated bed. From January 30 to February 6 the temperatures cannot be compared because the heat was accidentally left off. It is interesting to note, however, that the temperature did not become so low in the heated as in the unheated bed. This was due to the retention of the heat in the soil for several days after the electricity was turned off. From February 6 to March 6, the period when the beds were uncovered, the temperature in the one bed that was still being heated was about 11 degrees warmer than in the unheated.

The results obtained in the covered frames were in complete accord with those secured in the uncovered and open-field beds. They also indicated that the beneficial effect of soil heating was in the early stages of growth and that continuous heating was not necessary. In each instance the heated plots began blooming first and at practically the same date (fig. 8). The time required, however, for 75 per cent of the plants to bloom was considerably shorter on the plots heated 91 and 63 days than on the one heated for 35 days. All varieties except Bothkin showed a more favorable response to the 63-day period. In practically all varieties, 75 per cent of the heated corms had been cut before 25 per cent of the unheated were harvested.

The percentage of corms producing flowers shows slight variations in the different treatments. Since these differences exhibit no definite trend, they are probably caused by conditions other than exposure to soil heat.

SUMMARY

The time required for gladiolus to bloom was shortened from two to six weeks by heating the soil with electricity to a temperature of between 60° and 70° F.

Heating for about 60 days gave as good results as heating for about 100 days—in some cases better.

Heating for 35 days was beneficial but did not give as good results as heating for 60 or 100 days.

The quality and number of spikes produced was not affected by heat ing the soil.

The cost of heating the soil depends upon the temperature maintaine and the method of planting. With electricity at $0.02 per kilowatt hou the cost of heating the soil in an uncovered frame was $0.024 per squar yard per day for maintaining a temperature about 16° above norma In raised beds in the open field, the cost of heating was $0.039 an $0.021 per square yard per day for increasing the temperature 16° an 11°, respectively. In frames covered with wax-impregnated muslin, th cost of heating was about $0.025 per square yard per day for increasin the temperature 20°.

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